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INSTITUTE OF PETROLEUM.

An Ordinary General Meeting of the Institute of Petroleum was held at Manson House, 26 Portland Place, London, W.1, on January 11, 1950. The President, Mr E. A. Evans, presided during the early part of the proceedings.

The Minutes of the preceding Ordinary General Meeting, held on December 14, 1949, were read, confirmed, and signed.

The General Secretary (D. A. Hough) read the lists of elections to membership since the last general meeting, in accordance with the By-Laws.

He also announced particulars of the next general meeting of the Institute, to be held on February 8; the social evening on February 2; and the Annual Dinner of the Institute on February 28.

A symposium followed, on the testing of liquefied gases and light distillates, of lubricants, and of bitumen, and on standardization in oil measurement and sampling.

The President, introducing the subject, said: The scientist in the course of his studies has to handle many repulsive things. But we are not here to talk about them this evening. We are here to show that the scientist's role is to demonstrate facts. There the scientist stops. If it were otherwise he would be influenced by every prejudice and every error.

This briefly explains our aim in standardization. Standardization of methods of testing petroleum products looks so simple until a careful examination is made. Then we find that, if we are to deal with facts instead of suppositions, we are soon submerged in numerous difficulties and the only hope of rescue is by scientific enquiry. By such a procedure the old methods are receiving the fate they deserve. Traditional prejudices must go, not because we want standard methods for some intellectual and emotional security, but for their commercial utility. The normal man wants a standard that is always ready and easily applied.

Standardization is not the task of the few, but of the multitude. In this work we have several hundred people searching, sorting, and satisfying. This evening we have but four, describing the work and trends of their teams. We cannot tell you all about our extensive work on standardization in one meeting, and so we have selected a sample from which you can judge the rest.

(The President invited Mr F. L. Garton, the Deputy Chairman of the Standardization Committee, to preside during the presentation and discussion of the papers.)

F. L. Garton, having occupied the Chair, said: Before the presentation of the papers, perhaps I may say a word or two as to how this meeting

came about. The Standardization Committee is very mindful of the desirability of international agreement on standardization, so that we can all use the same testing methods and be able to get the same kind of results; we shall then be able to speak the same language in testing.

As many of you may know, the President has paid a visit to the U.S. recently, where he attended a meeting of the A.S.T.M. and had discussions with a number of people interested in standardization. The discussions he has had there have probably gone a long way towards drawing the A.S.T.M. and the I.P. more closely together. I think it is the very first necessity in international standardization that those two bodies, the two largest standardizing bodies in petroleum testing, should get together.

On several occasions during the last couple of years or so we have had visitors to the U.K. from the U.S. and from European countries, visitors who are very much interested in standardization. We have taken advantage of the opportunities offered for discussing standardization problems with them. On several of those occasions we have arranged, often at short notice, somewhat informal meetings of the chairmen of Standardization sub-committees, who have discussed the work of their sub-committees with the visitors. I think these meetings will also bear good fruit in the future. Several of us thought that other members of the Institute might be interested in similar summaries of the work of the Standardization Committee, and the President himself suggested that this symposium be held.

As there are fourteen active sub-committees of Standardization Committee, obviously it would be impossible to present the work of them all at one meeting and still allow time for discussion. Therefore, we have chosen four sub-committees, covering a fairly wide range of interest, and I think the large attendance to-night is sufficient indication of the interest in standardization work.

We hope we may be able to organize similar symposia at which the work of other sub-committees can be presented. The object of the papers is to tell briefly what the committee is doing, what it is hoping to do in the future, and to give members an opportunity to comment on and to discuss the work. As the President has indicated, a considerable number of people in the Institute are involved in this standardization work, and there is very close contact in many cases between the different sub-committees, since a given method may be used for several different products.

The following four papers were then presented by their authors.

A SYMPOSIUM ON THE TESTING OF LIQUEFIED GASES AND LIGHT DISTILLATES, OF LUBRICANTS, AND OF BITUMEN, AND ON STANDARDIZATION IN OIL MEASUREMENT AND SAMPLING.

THE WORK AND PROGRAMME OF SUB-COMMITTEE NO. 1—MEASUREMENT AND SAMPLING.

By H. Hyams* (Fellow).

Summary.

The paper deals briefly with the development of the work of the Institute of Petroleum on standardization relating to oil measurement. An indication is given of the literature which has already been published in the name of Sub-Committee No. 1 and the considerable work now in hand in the production of an oil measurement manual and a comprehensive book of oil measurement tables, the latter jointly with the American Society for Testing Materials. The future programme is also touched upon, and a tribute is paid to the warm co-operative spirit displayed by A.S.T.M., with the corresponding Committee of which Sub-Committee No. 1 has worked in close unison for seventeen years.

Introductory and Historical.

Standardization work in oil measurement and sampling is carried out by a special Oil Measurement and Sampling Sub-Committee of the Standardization Committee of the Institute of Petroleum. This Sub-Committee has been in being since 1932, and is now called "Sub-Committee No. 1." Its work falls into two main divisions :—

(*a*) *The preparation, revision, and keeping up to date of two standard methods of test which appear in "Standard Methods for Testing Petroleum and Its Products." These two methods, sampling and specific gravity, are the responsibility of the Sub-Committee due to their direct association with the measurement of oil.*

Samples are required in the measurement of bulk quantities of liquid petroleum products for the determination of the average temperature of the contents of storage and transport containers ; and the specific gravity is used for the purpose of converting volumetric quantities of liquids to the equivalent weights and for the correction of volumes to a standard temperature.

(*b*) *The study of all the processes and equipment which are concerned with the measurement and sampling of petroleum and allied products, with a view to preparing recommended standardized procedures (with associated apparatus or equipment) and instructions.*

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* Shell Petroleum Co. Ltd.; Chairman of Standardization Sub-Committee No. 1.

The results of the past work of the Sub-Committee, in addition to the production of the two test methods, may be briefly summarized as follows:—

Conversion Factors.

At the 1932 Annual General Meeting of the Institute, the President drew attention to the urgent need for an authoritative publication on the subject of the various national fundamental units generally used in the petroleum industry and the interconversion of such units. As a result of a study of the subject, the Sub-Committee produced "Measurement of Oil in Bulk—Part I."[1] The preparation of this publication involved a thorough examination of a wide field of metrology and the factors generally used in the industry for the conversion of oil quantities from one system to weights and measures to another. The published tables of interrelation of these measurement units are now widely recognized in the oil industry, and indeed elsewhere.

Measurement by Volume.

In 1933 and 1934 the Institute, through Sub-Committee No. 1, took a leading part in providing platforms for a discussion on the possibility of the petroleum industry universally adopting volume as the sole basis for expressing measured oil quantities. At the First World Petroleum Congress, held in London in 1933, the late J. McConnell Sanders, a member of the Sub-Committee, presented a paper on "The Measurement of Oil by Volume."[2] Subsequently, a letter on the subject was prepared by the Sub-Committee, and addressed to selected large users of petroleum products in bulk in the United Kingdom and in Europe. At a special I.P. Meeting in 1934 McConnell Sanders presented on behalf of the Sub-Committee a further paper entitled, "On the Advantages Secured by Expressing Quantities of Liquid Petroleum Products in Terms of Volume or Capacity rather than of Weight."[3] The greater part of this paper was devoted to giving adequate replies to those who had made comments or suggestions relative to the letter addressed to them by the Sub-Committee. The paper urged very strongly the exclusive use of volume for the measurement of oil in commercial transactions.

Before taking steps to implement the decision taken at the First World Petroleum Congress that measurement of liquid petroleum by volume should replace measurement by weight, the Institute felt it necessary to collect further data on expansion of petroleum products. Work on this subject was therefore undertaken by the Sub-Committee, but was not completed till 1941, at which time the question of weight versus volume could not, of course, be pursued further. However, sooner or later the question will have to be raised again.

Oil-Measurement Tables.

The Sub-Committee then turned its attention to Part II of "Measurement of Oil in Bulk," that is, to the production of standard oil-measurement tables applicable to the British system of weights and measures. Whether volume or weight is used for the measurement of oil it is necessary to have a knowledge of the thermal-expansion characteristics of the oil in question,

and as has already been stated the Sub-Committee accordingly decided to collect further data on the thermal expansion of petroleum products. In 1941 the results of these studies were published in the form of a report [4] on materials ranging from aviation spirits to asphalts, collected from sources throughout the world, and including products derived from cracking, from solvent extraction, and from other modern refining processes. The data contained in this report corroborated the wide applicability of the standard petroleum tables contained in U.S. Bureau of Standards " Circular C.410." Accordingly, the Sub-Committee decided to construct tables which would be in close alignment with the American tables, and in 1945 " Tables for Measurement of Oil " [5] was published.

Principles Governing Oil Measurement.

The Sub-Committee had meanwhile also been giving its attention to the preparation of recommended standard procedures for oil measurement, and 1945 also saw the publication of a document entitled " Principles Governing Oil Measurement Procedure." These principles had been agreed with the A.S.T.M., and were published simultaneously in I.P. " Standard Methods " [6] and in A.S.T.M. " Report of Committee D–2."[7]

Measurement of Oil Depths and Tank Calibration.

The progress made by the Sub-Committee during the war years was reflected by the publication in 1945 of " Measurement of Oil Depths " [8] as a tentative standard, and in 1948 of " Tank Calibration."[9] " Measurement of Oil Depths " now has the status of a standard method, and " Tank Calibration," which covers vertical cylindrical tanks only, that of a tentative standard.

Current Work.

The Sub-Committee as at present constituted is comprised of eight Panels which deal with the following subjects :—

A. Tank calibration.
B. Gauging.
C. Sampling.
D. Temperature measurement.
E. Specific gravity.
F. Units, calculations, and tables.
G. Apparatus and equipment for oil measurement.
H. Measurement of blends of petroleum products with coal-tar products

The current work of the Sub-Committee, in addition to the previously mentioned work in connexion with "Standard Methods for Testing Petroleum and Its Products " includes the preparation of an " Oil Measurement Manual," and the production, jointly with the A.S.T.M., of a comprehensive book of oil-measurement tables covering the U.S., British, and metric systems of measurement.

In the preparation of the publications on recommended standard procedures for oil measurement, Sub-Committee No. 1 has recognized that, in

general, three standards of accuracy are required in oil measurement, viz. :—

(*a*) *Simple but reasonably accurate methods suitable for internal operations in refineries, marketing installations, etc.*
(*b*) *More accurate methods for evaluating quantities of oil purchased and sold, and for fulfilling contractual obligations.*
(*c*) *Highly accurate methods for loss-control or referee work.*

The methods at present under preparation are being drawn up to satisfy fully the requirements of (*b*) above, and, where necessary, alternative more elaborate procedures are being given in order that the requirements of (*c*) above can also be met. The various methods will be collected into one comprehensive manual of oil measurement procedures covering the following six branches of oil measurement :—

(1) Tank calibration.
(2) Gauging.
(3) Sampling.
(4) Temperature measurement.
(5) Specific gravity.
(6) Calculation of oil quantities.

Each section is being prepared by the appropriate panel, and will be written in a form suitable for the guidance of supervisory staff, not necessarily as a field manual for gaugers. It is the view of the Sub-Committee that the preparation of a field manual is best left to individual oil companies, in order that they can suit their own particular needs.

Details of the stage which has been reached by each panel in the preparation of the manual are given later.

In addition to the section of the manual covering the calculations of oil quantities the Units, Calculations, and Tables Panel is engaged in the preparation of all the oil-measurement tables. These tables are being calculated independently by the A.S.T.M., and arrangements have been made for complete checking of all calculations by both A.S.T.M. and Sub-Committee No. 1.

The present stage reached in the work of individual panels is as follows :—

Panel " A "—Tank Calibration.

Since all the better-known types of storage vessels may be calibrated either by " strapping," *i.e.* measurement of external circumferences, by measurement of internal diameters, or by water-filling, these three methods will eventually be included in the tank-calibration section of the manual. The water-filling method has not, however, yet reached the drafting stage.

Procedures have been laid down for the calibration of vertical as well as horizontal cylindrical tanks by both the internal- and external-measurement methods. The procedure for vertical cylindrical tanks constitutes a revision of the tentative standard published in 1948, due account having been taken of the comments received since its publication. Alternative mathematical

approaches to the problem of the calculation of the partial contents of horizontal cylinders which are tilted have been given full consideration. Panel " G " (Apparatus) has prepared specifications for the apparatus and equipment used in these methods.

Care has been taken in the recommendations given for vertical cylinders to ensure that, provided all the specified precautions are taken in both the circumference- and diameter-measurement methods, they shall give closely identical results, and the procedure for making allowance for the expansion of the tank shell due to pressure of head of liquid has been set down. This procedure includes a suitable theoretical correction to allow tanks to be measured in any condition from empty to full. Tolerances allowed in the accuracy of the apparatus used and in the calibration measurements are such that an overall accuracy of 2 parts in 10,000 in the final tank table is obtainable.

Panel " B "—Gauging.

The recommendations of this Panel published in 1945 as a tentative standard method [8] have since become a standard method, and the work of preparation of the second section of the manual has consisted chiefly of rewriting the previous recommendations in the form required. Additional features have, however, been included, such as the procedure for the gauging of liquefied petroleum gases. The specifications for apparatus in this section were also prepared by Panel " G."

Panel " C "—Sampling.

This Panel is responsible for I.P. Method No. 51 " Sampling Petroleum and Its Products." During the last year the method has been thoroughly revised. Important features of this revised method (which will be included in the 1950 edition of " Standard Methods ") are a new method for sampling crude oil, the inclusion of methods for sampling for vapour-pressure determination, sampling of liquefied petroleum gases, and the recommendation of a new apparatus for taking bottom-settlings samples from storage tanks. Alterations in terminology for such items as " top," " middle," " bottom," " upper," and " lower " samples, etc., have brought the Panel's definitions into line with those used by the A.S.T.M. The levels specified for taking upper, middle, and lower samples from storage containers are now respectively one-sixth, one-half, and five-sixths of the net oil depth, again bringing the A.S.T.M. and Panel " C " recommendations into line.

The liquefied petroleum gases section of the revised sampling method has been prepared in conjunction with the Petroleum Gases Panel of Sub-Committee No. 3.

The " Eagle " bottom sampler, after an exhaustive series of tests, has been recommended in preference to the " Hemsley Bell " bottom sampler for the purpose of taking samples from very near the bottom of storage tanks.

For Section 3 of the oil measurement manual, the Panel is taking the revised sampling method mentioned above and extracting and adapting appropriate sections of the method so that they are applicable to the sampling for bulk-oil-measurement purposes as opposed to sampling for qualitative purposes. This work of adaptation is making good progress.

Panel " D "—Temperature Measurement.

Owing to the several changes in chairmanship, the progress made by this Panel during recent years was somewhat slow, but the speeding up of their efforts in recent months has resulted in their section of the manual now being ready to receive the Sub-Committee's approval. They have prepared a comprehensive document setting down standard procedures and apparatus to be used in determining the average temperature of the contents of an oil container. It is clearly necessary that an oil container should be well sampled for temperature measurement, and great attention has been paid by the Panel to such items as the levels at which samples should be taken for temperature determination, alternative types of apparatus for taking these samples, and minimum immersion times for the different types of apparatus. Consideration of the various types of apparatus was given in conjunction with Panel " G," whilst thermometer specifications and recommendations for checking the accuracy of thermometers were prepared in conjunction with Sub-Committee No. 10 (Apparatus).

The relatively high thermal-expansion characteristics of the lighter petroleum hydrocarbons necessitate close attention being paid to the measurement of the average temperature of an oil container with the best possible accuracy. The Temperature Measurement Panel has accordingly avoided going into print too early with its recommendations. And in this work, more than in that of any other Panel, with the possible exception of that covering tables, there has been the closest interchange of views with the Panel's " opposite number " in the A.S.T.M.

Panel " E "—Specific Gravity.

Panel " E " has produced a completely up-to-date revised version of I.P. Method No. 59, and this appears in the 1949 edition of " Standard Methods." The salient features of this revised method are the recommendation of modern type specific-gravity bottles and graduated pyknometers, the inclusion of a Modified Chancel Flask Method for the determination of the specific gravity of gases, and the exclusion of the Flotation Method for determining the specific gravity of paraffin wax.

Difficulty in obtaining the necessary apparatus for determining the specific gravity of liquefied petroleum gases by means of the pressure hydrometer has held up work on this subject, but efforts are still being made to obtain this apparatus and to investigate its possibilities.

For inclusion in the specific-gravity section of the oil measurement manual, such sections of I.P. Method No. 59 as are specially applicable to the measurement of oil quantities have been segregated and are being rewritten. The specific gravity of a petroleum liquid is essential for the conversion of a volumetric quantity to the equivalent weight and for the correction of volumetric quantities to a standard temperature.

Panel " F "—Units, Calculations, and Measurements.

With the publication in 1945 of " Tables for Measurement of Oil " [5] there were in existence authoritative oil-measurement tables for the U.S. and British systems of measurement, but not for the metric system. The attention of the Panel was accordingly then directed towards the production

of standard tables applicable to the metric system. A proposal that such tables should be jointly sponsored by the appropriate American and British authorities, that is the A.S.T.M. and I.P., was favourably received in Britain and in the U.S.A. In view of the Institute's closer contacts with Europe, they took the initiative by indicating what these metric tables might comprise. During 1947 a full exchange of views took place between A.S.T.M. and I.P. on oil-measurement tables, and the decision was taken to publish jointly a comprehensive set of oil-measurement tables in the American, British, and metric systems, the range of the tables to include liquefied petroleum gases and products in the bitumen range. The considerable correspondence which developed advanced the broad outlines of the contents of the proposed book of oil-measurement tables, and after visits to Britain by A.S.T.M. representatives in 1948 and 1949, agreement was reached on the details of content, range, style, and format of each table to be included, and the formulæ on which they were to be calculated. The joint publication will comprise thirty-seven tables in all, and the gravity and volume-reduction tables will be based on U.S. Bureau of Standards " Technologic Paper No. 77," upon which the Bureau of Standards " Circular C.410 " and the I.P. " Tables for Measurement of Oil " were calculated. The existing tables in these publications will be re-calculated and extended both in gravity and temperature ranges. Metric density and the metric volume-reduction tables will be based upon the same original data so that the tables will give equivalent results on any given quantity of oil, in whichever of the three systems of measurement (U.S., British, or metric) the quantity computation is made.

For the tables covering liquefied petroleum gases the appropriate section of the tables will be constructed from the experimental data upon which the Natural Gasoline Association of America based their " Standard Factors for Volume Correction and Specific Gravity Conversion of Liquefied Petroleum Gases and Volatile Gasolines." For products in the bitumen range, the tables will be constructed by extrapolation of the data in " Technologic Paper No. 77."

The standard temperature agreed by the A.S.T.M. and the I.P. for the U.S. and British systems of measurement is 60° F, and since 15° C is close to 60° F, it has been agreed to adopt 15° C as standard for tables in the metric system. It is realized that 20° C is widely used as the standard reference temperature for scientific work, but for the commercial measurement of petroleum products, whether the measurement is expressed in terms of volume at some standard temperature or in terms of weight, the standard temperature which is selected as a reference basis should be close to the average temperature at which unheated petroleum products are stored. For Great Britain and the United States of America that average temperature is slightly below 60° F, and for European countries it is thought that 15° C will be suitable. Since the American and British petroleum industries have definitely decided on 60° F as their standard temperature, and since 15° C is only 1° F lower than 60° F, it is obvious how advantageous it is to have the standard temperature as nearly as possible identical in a standard book of tables for industrial use.

A list of the titles of the thirty-seven tables will be found as an appendix to this paper. Those who are in any way familiar with either " Circular

C.410 " or the I.P. " Tables for Measurement of Oil " will realize that in so far as the total number of pages in the complete manual is concerned, approximately three fourths of these will be taken up by only six out of the thirty-seven tables. These lengthy tables are those concerned with the reduction of observed gravity or density to standard temperatures; and the reduction of volume at observed temperature to volume at standard temperature. In order to avoid the necessity for a prospective user being put to the expense of purchasing the complete set of tables when he would not require them all, it has been decided, at least by the Institute, that each table shall be published in pamphlet form, and punched for inclusion in a ring binder. In addition, the six lengthy tables just mentioned may possibly be issued in sections of limited gravity or density range, so that users who normally deal with petroleum products falling within a limited gravity or density range need not purchase the complete table. The size of the pages will be about 7 inches wide by 10 inches deep; this will allow of a wider margin than that in the I.P. " Tables for Measurement of Oil," the wider margin being necessary for punching in view of the decision to publish in pamphlet form for inclusion in a ring binder.

All tables in the manual will cover a density range 0·500 (or sometimes slightly below) to 1·100, or the equivalent in specific gravity, with the exception that no table entered against degrees A.P.I. will show entries outside the range 0° A.P.I. to 100° A.P.I. All the density and gravity reduction tables will incorporate the effect of the thermal expansion of the glass apparatus with which the density or gravity is determined.

The overall object in compiling the manual of tables is the achievement of the best possible accuracy in the commercial measurement of bulk-oil quantities. The tables in the manual will be given to a sufficient number of significant figures to ensure that the accuracy which has been technically attained in the other oil-measurement operations is not lost in subsequent arithmetical calculation.

Great care will be taken in the construction of all tables in the manual so as to be as certain as possible that the use of any table or series of tables will lead to the same result whichever system of measurement is used. It will be, however, impossible to secure complete arithmetical identity, and differences of the order of one part in about ten thousand will occur.

The Institute of Petroleum is keeping the British Standards Institution in touch with this programme, and the American Society for Testing Materials is likewise keeping the American Standards Association advised; this with a view to presenting the complete " Manual for Oil Measurement Tables " for subsequent international acceptance through the International Standards Organization.

In addition to the calculation of the tables just mentioned, Panel " F " is engaged in compiling Section 6 of the oil measurement manual, which deals with the calculation of oil quantities.

Panel " G "—Apparatus.

This Panel functions only when called upon by other panels, and the work carried out by them has been mentioned in connexion with the work of the individual panels of Sub-Committee No. 1.

Panel " H "—Measurement of Blends of Petroleum with Coal-tar Products.

The work of this Panel has, so far, been confined to gasoline–benzole blends. Discrepancies arising from the specific gravities which have been determined have necessitated complete replanning of the programme of work. Progress is accordingly slow.

Future Work.

The Sub-Committee has, as will be realized from the foregoing account, plenty of work on hand at the present time, but even with the completion of that work their task will by no means have been finalized. In the future they will have to consider revisions of published procedures in the light of experience, and take due note of comments and suggestions which may be received from users. In addition, the need will undoubtedly arise for investigational work on new methods and new apparatus.

Panel " A " will be required to produce procedures for the calibration of spherical- and spheroidal-type tanks, as well as recommendations for the calibration of various types of tanks by the water-filling method. The present recommendations with regard to the corrections for expansion of tanks under oil head have been made with rather less experimental evidence to support them than the Panel would have liked, and there is room for further field work in this direction. Again, the present recommendations lead to tank capacities which are correct at a standard temperature of 60° F, and the volume reduction factors being computed by Panel " F " make no allowance for the thermal expansion of storage tanks. There is room for much experimental work in conjunction with Panel " F " in order to collect data on the temperature of tank shells under varying thermal conditions.

Panel " B " will have to consider the growing use of positive displacement meters and the possible simplification of gauging work by the use of remote-control devices.

Panel " C " will undoubtedly be confronted with the work of evolving reliable sampling methods for the many newer volatile and chemical products which are rapidly becoming commercially available.

Panel " D " can do further temperature-measurement research work, particularly with regard to the design of apparatus which will lead to a reduction in the present rather long immersion times for certain types of temperature-measurement apparatus.

Panel " E " could usefully turn their attention to devising methods of determining minute changes of gravity due to the loss of volatile components in petroleum products, with a view to the use of this information in loss-control work.

Panel " F," with the publication of the joint A.S.T.M/I.P. oil measurement tables, will have performed a monumental task, and should these tables achieve, as is confidently expected, international acceptance, the Sub-Committee can be congratulated on having passed a milestone in the history of international standardization. There is, however, the disturbing

thought that the gravity and volume-reduction tables at present being compiled are based on the average properties of a great number of petroleum products, and that whilst the averages themselves may not alter, the wider variety of crude oils which become available and the new distillation and treating processes may result in the production of individual products whose properties are far removed from that average. There is no doubt too that the production of large quantities of petroleum chemicals will raise the need for standardized procedures for the calculation of volume and weight quantities of these products.

Work carried out by the U.S. National Bureau of Standards, resulting in the issue of their " Research Paper No. 244 " and " Research Paper No. 393," has shown that the thermal behaviour of oils such as gas oils and lubricating oils of a wide variety of types can be closely correlated with density and viscosity, and that the thermal expansion of a gasoline can, generally, be more accurately correlated with the " average volatility " of the product than with its density.

The U.S. National Bureau of Standards have also published the results of work they carried out on the correlation of the thermal properties of C_4 hydrocarbon mixtures with vapour pressure.

From all of this work on thermal expansion of petroleum products it would be possible to construct complex tables of improved accuracy, but only by introducing the need for special measurements in order to apply these tables. It is also doubtful whether, because of their greater complication in routine use, such tables calculated on these physically better bases would be acceptable to the petroleum industry. Until the petroleum industry has decided on this point, the A.S.T.M. and I.P. have felt it better to maintain the present basis of tabulation, but there is undoubtedly scope for a good deal of future work in this direction by Panel " F."

When Panel " H " has acquired the information necessary for the preparation of tables for the gravity and volume reduction of gasoline–benzole blends, their attention must be turned to other mixtures of petroleum and non-petroleum products, such as alcohol. The fact that in some cases the proportions of the blend will not be known will render triple-entry tables necessary for close tabulation.

Conclusion.

The principles underlying practical standardization have been borne in mind by Sub-Committee No. 1 in the task on which they have been engaged. It has been realized that if quantitative measurements of the vast quantities of gaseous, liquid, and solid petroleum products which change hands each year are to win the ready acceptance of the parties concerned, the methods by which such measurements are taken must not only be standardized and agreed, but the standardization procedures must also have real and practical application in petroleum commerce.

This paper should not conclude without reference to the close co-operation in oil-measurement-standardization work which has existed between the I.P. and the A.S.T.M. since the Institute first initiated that co-operation in 1932. No two national technical committees could have worked together more intimately and with greater understanding of each other's local

problems. We have carried our work forward step by step in close unison, and the forthcoming joint book of oil-measurement tables under the imprint of A.S.T.M. and I.P. is the practical evidence of the contribution of our two bodies to worthy work in the interests of mutual understanding and the promotion of international trade.

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[2] *Proc. World Petrol. Congr.*, 1933, II, 866–868.
[3] *J. Inst. Petrol. Techn.*, 1934, **20**, 665.
[4] *J. Inst. Petrol.*, 1941, **27**, 402.
[5] "Tables for Measurement of Oil," Institute of Petroleum, 1945, p. 320.
[6] "Standard Methods for Testing Petroleum and its Products," Institute of Petroleum, 1945, p. 525.
[7] "A.S.T.M. Standards on Petroleum Products and Lubricants, Report of Committee D-2," 1945.
[8] *J. Inst. Petrol.*, 1945, **31**, 40.
[9] *J. Inst. Petrol.*, 1948, **34**, 288–308.

Appendix.

Complete List of Tables to be included in The A.S.T.M/I.P. Manual of Oil Measurement Tables.

Table 1.—Interrelation of units of measurement.
Table 2.—Reduction of observed ° A.P.I. to ° A.P.I. at 60° F.
Table 3.—Reduction of observed specific gravity to specific gravity at 60° F.
Table 4.—Reduction of observed density to density at 15° C.
Table 5.—Volume at 60° F occupied by unit volume at indicated temperature against ° A.P.I. at 60° F.
Table 6.—Volume at 60° F occupied by unit volume at indicated temperature against specific gravity at 60° F.
Table 7.—Volume at 15° C occupied by unit volume at indicated temperature against density at 15° C.
Table 8.—Abridged volume correction factors (based on ranges of A.P.I. gravity).
Table 9.—Abridged volume correction factors (based on ranges of specific gravity).
Table 10.—Abridged volume correction factors (based on ranges of density).
Table 11.—° A.P.I. at 60° F. to specific gravity at 60° F and density at 15° C.
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Table 13.—Density at 15° C to ° A.P.I. at 60° F and specific gravity at 60° F.
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Table 15.—Pounds per U.S. gallon at 60° F and U.S. gallons at 60° F per pound against specific gravity at 60° F.
Table 16.—Pounds per imperial gallon at 60° F against specific gravity at 60° F.
Table 17.—Kilograms per litre at 15° C and litres at 15° C per metric ton against density at 15° C.
Table 18.—Short tons per 1000 U.S. gallons at 60° F and per barrel at 60° F against ° A.P.I. at 60° F.
Table 19.—U.S. gallons at 60° F and barrels at 60° F per short ton against ° A.P.I. at 60° F.
Table 20.—Short tons per 1000 U.S. gallons at 60° F and per barrel at 60° F against specific gravity at 60° F.
Table 21.—U.S. gallons at 60° F and barrels at 60° F per short ton against specific gravity at 60° F.
Table 22.—Long tons per 1000 U.S. gallons at 60° F and per barrel at 60° F against ° A.P.I. at 60° F.
Table 23.—U.S. gallons at 60° F and barrels at 60° F per long ton against ° A.P.I. at 60° F.
Table 24.—Long tons per 1000 U.S. gallons at 60° F and per barrel at 60° F against specific gravity at 60° F.
Table 25.—U.S. gallons at 60° F and barrels at 60° F per long ton against specific gravity at 60° F.

Table 26.—Long tons per 1000 imperial gallons at 60° F against specific gravity at 60° F.
Table 27.—Imperial gallons at 60° F per long ton against specific gravity at 60° F.
Table 28.—Long tons per 1000 cubic feet at 60° F against specific gravity at 60° F.
Table 29.—Long tons per water ton at 60° F against specific gravity at 60° F.
Table 30.—Short tons and long tons per 1000 litres at 15° C against density at 15° C.
Table 31.—Litres at 15° C per short ton and per long ton against ° A.P.I. at 60° F.
Table 32.—Litres at 15° C per short ton and per long ton against specific gravity at 60° F.
Table 33.—U.S. gallons at 69° F, barrels at 60° F, and imperial gallons at 60° F per metric ton against density at 15° C
Table 34.—Metric tons per 1000 U.S. gallons at 60° F and per U.S. barrel at 60° F against ° A.P.I. at 60° F.
Table 35.—Metric tons per 1000 Imperial gallons at 60° F against specific gravity at 60° F.
Table 36 (a).—Litres at 15° C per U.S. gallon at 60° F against ° A.P.I. at 60° F.
Table 36 (b).—Litres at 15° C per U.S. barrel at 60° F against ° A.P.I. at 60° F.
Table 36 (c).—Litres at 15° C per U.S. gallon at 60° F against specific gravity at 60° F.
Table 36 (d).—Litres at 15° C per U.S. barrel at 60° F against specific gravity at 60° F.
Table 36 (e).—Litres at 15° C per imperial gallon at 60° F against specific gravity at 60° F.
Table 37.—U.S. gallons at 60° F and imperial gallons at 60° F per litre at 15° C, and barrels at 60° F per 1000 litres at 15° C, against density at 15° C.

THE WORK AND PROGRAMME OF SUB-COMMITTEE NO. 3—GASES AND LIGHT DISTILLATES.

By W. H. Thomas * (Fellow).

Introduction.

Towards the end of 1948, a review was made of the activities of Sub-Committee No. 3 in the light of current trends in the petroleum industry, and as a result it was decided that some minor changes were required in the general organization and format of the Sub-Committee.

In brief, these changes resulted in the disbanding of the Tetra-Ethyl Lead (T.E.L.) Panel, a change in title of what is now known as the Petroleum Gases Panel, and the formation of a secretarial link between the Hydrocarbon Analysis Panel and the Hydrocarbon Synthesis Panel of the Research Committee.

As a corollary, the membership of the Sub-Committee and its Panels was augmented to provide the personnel necessary for the widened scope of the Sub-Committee and for " user representation."

In presenting this review, it is proposed to deal in rotation with the activities of each panel, to summarize those activities which necessitated co-operation with other committees, and finally to indicate what the future lines of work would be.

Petroleum Gases Panel.

The first tasks of this Panel were to improve and augment the procedures for sampling and for the determination of specific gravity. These subjects

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were handled in conjunction with the appropriate panels of Sub-Committee No. 1, and it will be appreciated from a perusal of the appropriate sections of "Standard Methods" that this inter-panel co-operation was markedly successful. It must not, however, be assumed that the last word has been said on these two important subjects, and they are still "under review."

In the same way, the determination of the sulphur content of gases has been studied in association with the Sulphur Panel, and here again a satisfactory procedure and equipment has been evolved.

Yet another example of this method of carrying out the Panel's work is afforded by recent work done in connexion with heat of combustion. This was effected in collaboration with the Gas, Diesel, and Fuel Oil Sub-Committee (No. 4), and the Petroleum Gases Panel's recommendations are included in the new version of the calorific value method which appears in the current edition of "Standard Methods" as Method 12—Heat of Combustion.

The above items, important as they are, by no means constitute the bulk of the Panel's work, for it has studied in some detail the methods available for the analysis of hydrocarbon gases. Space here does not permit of a full account of all that has been done, but it should be observed that procedures, for analysis by distillation methods [1] and absorption methods [2] have been published, and are now on the verge of appearing as draft standard methods. Both of these methods require complicated and expensive apparatus, but it is felt that this disability should not prevent their issue, particularly as others, for example, those for engine testing, have been published as standard procedures in spite of the high cost and complexity of the apparatus.

Other tasks in hand concern the estimation of water in gases and the detection of gum-forming compounds which might cause trouble in gas-distributing systems. The question of corrosive sulphur is also in mind so far as it concerns liquefied gases, but as yet there is some uncertainty as to whether such an estimation will ever be required.

Future activities of the Panel seem to be almost unlimited. Dealing, as it does, with precise analytical procedures rather than with test methods, its association with the Hydrocarbon Synthesis Panel and the Spectroscopic Analysis Panel of the Research Committee will become increasingly closer. It is quite obvious that having dealt with distillation and absorption methods of analysis, the Panel will naturally turn to a study of spectroscopic methods, and the time is not far distant when the mass spectrograph and all it entails will come within the purview of the Petroleum Gases Panel.

Burning-Test Panel.

For quite a considerable time the main task of this Panel has been to improve the procedure for the determination of char value (I.P. 10) so as to obtain better repeatability of results. Much painstaking work has been done, and as a result of specifying the pretreatment of the wick and adopting more suitable methods for the removal and weighing of the char, it does appear that the Panel's work in this direction is nearing its end.

However, with the improvement and widening of the scope of kerosine-burning appliances, the problem of assessing the kerosine may be expanded.

For example, it is not known whether the existing burning-test results can be translated in terms of the performance of the kerosine in mantle lamps or in space-heating appliances.

Colour Panel.

The question of the colour of petroleum products is in general not an important one except as a ready means of identification to the user. Nevertheless, the refiner must be able to measure colour as part of his control of manufacturing processes, *e.g.*, certain types of lubricants and also waxes.

As regards the theoretical side of its work, the Panel has given much consideration to the C.I.E. system of colour units. Details of this system have already been published [3] and its advantages and disadvantages carefully assessed. In this article, however, it is sufficient to say that although these units have advantages for some purposes, it would prove difficult to visualize the meaning of colour expressed in C.I.E. units unless recourse could be made to the solid colour diagram. This, of course, is impossible, and this main difficulty will militate against the widespread adoption of the C.I.E. system, excellent though it is from the theoretical aspect.

The Panel's work on "Lovibond Colour" has been quite normal in character; cells for use in the determination of the colour of wax have been discussed, and also the provision of blue slides to augment the normal colours—red and yellow. The method (I.P. 17) has been redrafted to incorporate these modifications.

Some slight difficulty has arisen with regard to lamps for use with the Saybolt instrument, and in this case, as with many others, the difficulty is being solved by co-operation with another sub-committee, in this case the Apparatus Sub-Committee.

Gum Panel.

This Panel may be regarded as one of the most mature of the Standardization Committee, it having been responsible for the method of determining existent gum content, etc. It has studied potential gum, and breakdown time or oxidation stability of motor fuel. It might be imagined, therefore, that the Panel's work was complete, but there is still some considerable dubiety with regard to the precise definition of breakdown time. The specification for I.P. spirit is under review with respect to its allowable gum content and its use for the removal of lubricating oil from gum in residues obtained from contaminated fuels.

All the methods within the Panel's jurisdiction are being studied to see whether any revisions are considered necessary.

Recently, however, it has been felt that the Panel should include in its responsibilities a study of methods for determining stability. Not only gum stability but also that connected with the tetra-ethyl-lead component of motor fuels, and even colour stability could be brought within its purview.

With these enlarged terms of reference, therefore, it has been considered desirable, on the suggestion of Dr F. B. Thole, to alter the title of the Panel to that of Stability Panel.

Sulphur Panel.

The record of this Panel's work is quite outstanding. Its activities cover methods for determining total sulphur content, type of sulphur compounds, and corrosive sulphur tests.

As regards total sulphur content, there are four methods in the present edition of I.P. "Standard Methods"—the lamp, the fast lamp, the quartz tube, and the bomb methods. Each of these has its own main sphere of utility, though there is a considerable overlap in this respect.

The first of these will not be published in the next edition of "Standard Methods," its utility being fully covered by the fast lamp method (I.P. 107), which was introduced in 1945. The burner of the fast lamp was unique at that date, but, owing to its advantages, the principle has since been adopted by quite a large number of workers for specialized lamp combustions. The method I.P. 107 enables sulphur contents to be measured with a high order of accuracy and, when required, down to lower concentrations than was possible with its predecessor (I.P. 62).

Much interest is at present being shown in the I.C.I. vertical quartz tube method for total sulphur content. This method shows considerable promise, particularly with regard to the speed with which results can be produced and the very wide range of petroleum products which can be handled.

The bomb method is about to be reviewed for two reasons. First, in order to incorporate the recommendations of the Apparatus Sub-Committee for increasing the safety of such methods, and secondly, to adopt a procedure which will enable both sulphur and calorific value to be determined with the same bomb charge without loss of accuracy. It is hoped that contacts with the A.S.T.M. will bring agreement upon a common test procedure, especially in view of the fact that differences are already small.

Tests for specific types of sulphur compounds adopted during the last few years include those for hydrogen sulphide (I.P. 103), mercaptans (I.P. 104), and carbon disulphide (I.P. 108). The first two of these are destined for revision in order to extend their scope and bring them up to date.

In the midst of all these activities, the importance of corrosive-sulphur tests has not been forgotten. Of these, the copper-strip test has received most attention. Elemental and corrosive sulphur are not necessarily synonymous, and some of the complexities that are met when examining the corrosion of copper by sulphur bodies were revealed recently.[4] The authors, one of whom is a member of the Panel, have evolved a neat method for determining the corrosion of a copper strip in a quantitative manner in place of the visual descriptions that have been used in the past. The visual interpretation of a copper-strip test is often difficult, even when assisted by reference strips. The Panel as a whole has made intensive studies of copper-strip tests on more than one occasion, and the past year has been no exception. Unpublished work on the reduction potential of the corroded strips has increased our knowledge of the reactions involved, but more information is still desirable.

Future work will include the assessment of corrosive sulphur in liquefied gases. Information is being accumulated on methods that have been pro-

posed for use, and it is hoped that experimental work can be started during the coming session, probably in conjunction with the Liquefied Gases Panel.

Hydrocarbon Analysis Panel.

This is the youngest panel of I.P. Sub-Committee No. 3; it has a connexion with the Hydrocarbon Synthesis Panel, since it shares a secretary to the mutual advantage of both.

The Panel under discussion has a considerable programme of work in front of it but nevertheless has very wisely decided to limit itself to one or two outstanding items of current interest and importance. Of these, the method for the determination of aromatics is the obvious first choice. The matter in hand, therefore, at the moment is a study of the routine method for the hydrocarbon analysis of wide-boiling-range samples, and this actually involves a comparison of I.P. Method 3 with A.S.T.M. Method D. 875.

Accordingly, samples for correlation tests were prepared and circulated for analysis by both methods. This detailed examination of the two methods is still in hand, and already discussion on certain practical details such as the precautions necessitated by the mixing of acid with unsaturated hydrocarbons and the permitted variation in the strength of the acid are in hand.

As a corollary to all this work, there is the matter of the determination of bromine number and the possibility of improving the existing official procedure by the adoption of a type of electrometric titration. This, by the way, is becoming increasingly popular because of its applicability to coloured materials such as gas oils and diesel oils.

Finally, it should be observed that hydrocarbon-type analysis is one of the subjects on which it is hoped to obtain the closest possible co-operation with the A.S.T.M.

To complete this necessarily brief review of the activities of Sub-Committee No. 3, its chairman wishes to express his deep appreciation of the keenness and industry of its members and of those of the various constituent panels. It is, indeed, very encouraging in these difficult times, when technical men have so little time to spare in the normal working-day, to find that the " examination of petroleum " can still attract so much constant attention and deep interest.

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[2] *J. Inst. Petrol.*, 1949, **35**, 353–362.
[3] *J. Inst. Petrol.*, 1949, **35**, 221–244.
[4] *J. Inst. Petrol.*, 1949, **35**, 496–507.

THE WORK AND PROGRAMME OF SUB-COMMITTEE NO. 6—LUBRICANTS.

By R. S. Teale* (Fellow).

Functions.

Sub-Committee No. 6 is responsible for the formulation of physical and chemical methods for evaluating specific properties in lubricants other than greases. Since its inception it has formulated over forty I.P methods for testing lubricants, and is responsible for keeping these methods up to date and in line with general development; in fact, quite a large part of its work is concerned with this latter aspect.

In addition to this, it has the task of standardizing test methods for the evaluation of further properties of lubricating oils as the need may arise. Work in this connexion may consist in improving the accuracy of existing methods, or it may go farther and involve the choice of test conditions and apparatus as well as details of procedure.

Some examples of these different types of work may be useful in illustration. In the sphere of viscometry, for instance, various improvements in measurement of viscosity by the Redwood instrument were made at a very early stage, and refinements or cautions as to the limitations of the instrument have been added from time to time. Recently, the more accurate determination of viscosity has been under review.

As an example of the standardization of tests for additional properties, one may take a simple case first. During the war it became desirable to introduce I.P. standard methods corresponding closely with A.S.T.M. methods for the purposes of joint Service specifications. This work only entailed the selection of equivalent British materials, units, etc., and sufficient experimental work to show that the equivalent I.P. method did in fact give the same results as the original A.S.T.M. method. The standardization of a rust-protection test for turbine oil in the presence of seawater, equivalent to A.S.T.M. method D. 665–47T, is a case in point. However, in many cases, investigations involving much more fundamental researches are involved. Two examples of this may illustrate problems of this description.

During the war it was desired by the War Office to frame a specification governing the quality of H.D. diesel engine oils, and, as part of the specification, a test was required which would discriminate between approved 2–104B oils and all straight-mineral oils in respect of their tendencies to corrode special alloy bearings during the course of their service. I.P. Sub-Committee No. 6 was given general terms of reference in respect of the temperatures and metals involved, etc., and was asked to work out a short-term test which would give the required distinction. After a very large number of alternative conditions of oxidation had been tried out, a method was put forward and accepted by the Institute based on the loss of weight of lead specimens during a 12-hr test. Whilst the reproducibility of the method is not altogether satisfactory, it does distingush very sharply between the two types of oil in question.

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Another case, having a wider scope, concerns what are known as temporary protectives, in which no terms of reference as regards conditions of test are specifically laid down, but the aim is to frame test methods which will evaluate the protective properties of various classes of temporary protectives under conditions and exposure encountered in practice.

Constitution.

This Sub-Committee includes members of the oil industry, the Services, and large commercial users and, inclusive of panel members, numbers about 80. The work is carried out by the laboratories of the participating companies, and a number of panels have been formed to deal with various aspects of lubricating-oil testing.

At first the Sub-Committee worked as a unit, but it very soon became desirable to divide up the work, and panels were appointed to undertake specific lines of investigation. Among the earliest were those dealing with greases, viscometry, insulating oils, and turbine oils. During the war the introduction of inter-Service specifications gave rise to a need for many additional evaluation tests, and the Sub-Committee was reorganized. The Grease Panel was formed into a separate sub-committee, and a number of additional panels were added. Six panels are operating at present, namely, Viscosity, Oxidation, Inorganic Analysis, Cutting Oils, Temporary Protectives, and Miscellaneous Tests.

Work of the Panels.

Some of the more recent work of these panels and their more immediate future plans are as follows.

Viscosity Panel.

It may seem odd that the determination of viscosity is still a live issue after all these years. However, the accurate determination of viscosity is complicated and difficult, and is nevertheless extremely desirable from an international standpoint. The particular work of this Panel, which was started before the war, arose as a result of the different viscometer constants obtained in the U.K. and in the U.S.A., working on different primary fluids such as sucrose solution and water. The object is to produce an accurate viscometer for measuring the viscosity of a fluid whose viscosity is accurately known (such as water) which can then be used as a standard instrument for the measurement of the viscosity of secondary fluids of higher viscosity, using, for instance, in successive stages benzine, kerosine, and lubricating oil. Instruments for the purpose have now been manufactured, made of precision capillary tube of 0·045 cm bore and 40 cm in length, in which the kinetic-energy-correction factor is of a very low order. Various modifications are being tried, and, after the reproducibility of the results in eight different co-operating laboratories using water has been checked, the viscosity of other fluids will be accurately determined so that they can be used for calibrating viscometers of the suspended level, Fenske, and U-tube (B.S.) types. It is hoped at a later stage to exchange samples of standardized fluids with the A.P.I.

Arising out of this work, various other lines of activity present themselves, such as the viscosity of opaque fluids and of substances which do not have Newtonian properties. These further developments are naturally studied in co-operation with other sub-committees who are interested in viscometry.

Oxidation Panel.

Attempts to evolve a laboratory test method which will evaluate the oxidation properties of lubricants in the same way as service conditions extend back over very many years, and there are in fact probably more proposed tests for oxidation than for any other single property of lubricants. It is virtually impossible in any one test to include all the different oxidation influences to which an oil is subjected in an engine, and laboratory tests, therefore, tend to be foredoomed to failure in regard to the general evaluation of oxidation characteristics of I.C. engine oils. As already mentioned, however, this Panel has evolved a useful method for differentiating between corrosive tendencies of H.D. and mineral oils towards special alloy bearings, and it remains to be seen how this test lines up with engine data.

When the oil is exposed in practice to only a limited range of oxidizing influences, such as, for example, in turbines or transformers, evaluation by laboratory oxidation tests can be most useful. In these fields the Oxidation Panel has done a great deal of experimental work and has not only assisted in the development of an oxidation test for turbine oils which has recently been adopted by the British Admiralty, but has also investigated the causes of variability in the Michie test for transformer oils and has recently made a number of amendments designed to secure better repeatability.

Inorganic Analysis Panel.

The determination of inorganic elements in oil has latterly become of very great importance, not only in estimating additives in unused oil for control purposes, but also for examining the fate of the additive during use. It is also valuable for estimating the contamination of oil with salts of bearing metals or other adventitious impurities. Tests methods have already been formulated for a long list of elements including barium, calcium, zinc, iron, copper, lead, phosphorus, and chlorine. The test methods already introduced are being continually subjected to scrutiny from the point of view of accuracy and ease of manipulation, and alternative methods are being studied, including polarographic, spectrographic, and flame photometer methods, as well as the conventional gravimetric methods. Electrometric methods for the halogens and alternative methods for phosphorus as well as iron, copper, and lead are at present under investigation, and other metals are down on the further programme of investigation.

Cutting Oils Panel.

At the present moment, with the exception of the recent tentative method for estimating the corrosive tendencies of soluble-oil dispersions, there are no specific I.P. tests for evaluating cutting oils, and there is quite a wide field open in this direction.

Actual cutting properties are not within the scope of this Sub-Committee,

as they belong to the category of mechanical tests, but there are many tests carried out on cutting fluids which require standardization. The test already framed by this Panel for corrosive tendencies is not considered to be altogether satisfactory from a quantitative point of view, and work is in hand on the development of a more precise statistical method. Further work already in the programme includes :—

(1) *The extension of the corrosion test to other metals.*
(2) *The assessment of the stability of soluble-oil dispersions.*
(3) *The estimation of mineral-oil content of soluble-oil dispersions.*

Temporary Protectives Panel.

This newly formed Panel also has a very wide field of operation, and, as a commencement, a symposium of papers on the subject was arranged to be read before the Institute on March 29, 1950.

The need for temporary protectives arose acutely during the recent war, and many laboratory tests were hurriedly devised with the object of discriminating between the protective powers of various products. These included several different humidity cabinet tests in which steel specimens are exposed to water vapour temperatures, and also salt-water-spray tests, ultra-violet-light tests, and so forth. However, the reproducibility of most of these tests is very poor, and correlation with practice is on the whole unreliable.

Temporary rust protectives fall naturally into specific classes, such as oil-film type, soft-film solvent-deposited type, hard-film solvent-deposited type, hot-dip compound type, etc. The applications of these types of protective are widely different, and it may well be that a number of test methods are required for the evaluation of the various classes. The Panel is starting with fundamentals, and is distributing among its members a large number of carefully prepared steel plates for shed exposure in various parts of the country and for laboratory testing in humidity cabinets and by a method based on water droplets. Some idea of the scope of this initial work can be judged from the fact that for the first distribution 432 steel specimens were required.

Miscellaneous Tests Panel.

This Panel, which was formed in 1943, deals with the test methods not specifically covered by the other panels, and may, consequently, be called upon to tackle almost anything. Its recent work has included adaptation of the copper-strip corrosion test to lubricants and a great deal of work on acidity and saponification values. As originally laid down, both determinations gave difficulties with opaque oils, and the saponification value also tended to be inaccurate with oils of very low saponification value. The revised methods have eliminated these drawbacks, and a new method for saponification value, based on a solution of potash in Cellosolve, by which more rapid determinations can be carried out has also been put forward and accepted.

Work is now in hand to examine whether this new method can be used for waxes as well as lubricating oils, which is not the case with the present method, I.P. 52/48(T).

A re-investigation of the determination of diesel-fuel dilution in lubricants has been in hand for some time, and is giving a lot of trouble. The estimation of diesel-fuel diluent is complicated by the appreciable volatility of the lubricant in which the diluent may find itself. It is certain that for accurate determination a blank test must be carried out on the undiluted lubricant, but, even with this provision, a satisfactory method has not yet been evolved. Further work of this Panel includes the development of a test for foaming properties of turbine oils, diesel-engine oils, and gear oils, on the lines of the A.S.T.M. foaming test, and a re-assessment of the pour-point method in which some anomalies have recently been reported.

Future Work of the Sub-Committee.

As will be seen, the individual panels involved already have a full programme of work, necessitating a great deal of co-operative testing, and with the progressive development of lubricants in various specialized spheres there is no doubt that new specific properties will continue to require evaluation.

Apart from this general work, there are two immediate tasks to which attention is being given. First, a list is being considered of non-standard test methods used by important consumers in the U.K. with the object of ascertaining : (*a*) to what extent they could be replaced by existing I.P. method, and (*b*) whether appropriate I.P. methods should be formulated where no equivalent methods exist. Secondly, although by no means second in importance, is the desire to establish the closest possible correspondence between I.P. methods and those of the A.S.T.M. so that these can be considered interchangeable. There is, of course, some inevitable difficulty in writing identical descriptions of test methods owing to differences in apparatus and, in some cases, units on the two sides of the Atlantic, but obviously these difficulties are not fundamental, and it is anticipated that with the continually closer contact which is being established between the I.P. committees and the corresponding committees on the other side something in the nature of international test methods will finally be achieved.

THE WORK AND PROGRAMME OF SUB-COMMITTEE NO. 7—BITUMEN.

By C. F. Jackson * (Fellow).

One matter which has been receiving attention, very necessarily so, is nomenclature. It is perhaps fitting to commence with this in the hope that it may be clear what is this material "bitumen." Moreover, this may provoke useful discussion.

If the preface to any British Standard Specification concerning the use of the material now being discussed is studied, the following definitions

* Shell Petroleum Co. Ltd.; Deputy Chairman of Sub-Committee No. 7.

will be found. They are the so-called "international" ones drawn up by "The Permanent International Association of Road Congresses."

1. ***Bitumen.*** *Mixtures of hydrocarbons of natural or pyrogenous origin or combinations of both (frequently accompanied by their non-metallic derivatives) which can be gaseous, liquid, semi-solid, or solid, and which are completely soluble in carbon disulphide.*

2. ***Asphaltic bitumen.*** *Natural or naturally occurring bitumen, or bitumen prepared from natural hydrocarbons or from derivatives of natural hydrocarbons by distillation or oxidation or cracking; solid or viscous, containing a low percentage of volatile products; possessing characteristic agglomerating properties, and substantially soluble in carbon disulphide.*

3. ***Asphalt.*** *Natural or mechanical mixtures in which asphaltic bitumen is associated with inert mineral matter.*

The above differ fundamentally from American usage, which employs the word "asphalt" to mean what is commonly referred to in the U.K. as "bitumen," and more precisely under (2) above as asphaltic bitumen.

Sub-Committee No. 7 are of the opinion that the term "asphaltic bitumen" is unnecessarily cumbersome and that, since for as long as most can remember the simple term "bitumen" has been used with complete understanding of what was meant (being in fact the term normally used throughout the petroleum industry in the United Kingdom), it was agreed that the preface "asphaltic" should be dropped. This was done in co-operation with Nomenclature Sub-Committee No. 11 and The Association of Manufacturers of Bituminous Protective Products, and in the 9th edition (1948) of "Standard Methods for Testing Petroleum and its Products," the single word "bitumen" appeared throughout. In view of its complicated constitution, the formulation of a definition of this material has occasioned very considerable discussion on the committees concerned and not a few amendments and redraftings of the wording, the last being :

"***Bitumen:*** *A non-crystalline solid or semi-solid cementitious material derived from petroleum, which gradually softens when heated, consisting essentially of compounds composed predominantly of hydrogen and carbon.*

"*Bitumens are black or brown in colour. They may occur naturally or may be made as end-products from the distillation of, or as extracts from, selected petroleum oils.*"

This will then presumably be the definition officially sponsored by the Institute of Petroleum and recommended to the British Standards Institution and the Permanent International Association of Road Congresses, but the writer is not quite clear regarding the status of such a definition or indeed whose is the final responsibility for drawing up a definition of a material such as this. Being a petroleum product, presumably it should be the responsibility of the Institute at least in so far as the United Kingdom is concerned.

Testing Methods.

In common with the other products sub-committees, No. 7 is faced with the constant modernization of existing methods to keep abreast with the

current requirements as well as the introduction of entirely new methods. Indeed the most recent work of the Sub-Committee has been concerned largely with the former, although, as will be seen later, a great deal of new ground has been covered since the war, particularly for example on the subject of " soil stabilization."

Softening Point.

Two of the tests of longest standing and of great importance, both in view of their significance in specifications and in helping to classify bitumens according to type, have been receiving renewed consideration during the past year. These are the well-known ring and ball softening point (previously known as melting point) test and the penetration test. The former was last modified by the Institute in 1946, so as to provide mechanical stirring, with a view to ensuring uniform heat distribution throughout the bath. This was felt at the time to be a technically progressive step. A difficulty subsequently encountered, however, is the discrepancy between the results of this I.P. method and the A.S.T.M. method D 36–26, the latter being the test almost universally used for bitumen in the U.S.A. and in many other countries also. The results are $1\frac{1}{2}$–2° C lower, by the I.P. method. Moreover, from the point of view of practical accuracy it is somewhat difficult to justify the added complication of stirring, exhaustive tests having failed to indicate any insignificant improvement in repeatability or reproducibility. Certain laboratories make use of the relation between the results obtained by this test and those by the penetration test as a measure of temperature susceptibility or penetration index, which is affected to an appreciable extent by the stirring technique. The choice between the long-standing A.S.T.M. method relying on natural convection and the more academically impressive mechanical stirring has therefore to be reconsidered.

Penetration.

In view of very considerable modifications suggested by the A.S.T.M. in their D 5–47T the penetration test is also receiving attention at the present time. The American method has the disadvantage of requiring the provision of a thermostatically controlled air-cooling chamber in addition to the water-bath, as well as taking up to 2 hr longer to carry out. While the effect of the suggested modifications upon the results obtained has not so far been investigated as such, our experience would lead us to doubt any worthwhile advantage. It may well be, however, that the A.S.T.M. will never make this a full standard.

Asphaltenes.

Another test for future consideration is the " asphaltenes " determination, the suggestion having been made that a single method might be standardized for all petroleum products. It is anticipated that co-operation with Sub-Committee No. 2—Crude Oil, the Asphaltenes Panel of Sub-Committee No. 4—Gas, Diesel, and Fuel Oil, and Sub-Committee No. 6—Lubricants will result in some conclusion being reached in this connexion in the near future. Any suggestions from the present meeting will, of course, be valued.

Flash Point.

For many years the determination of the flash point of cutback bitumen was carried out variously and frequently rather unsatisfactorily, in the Cleveland, the Pensky-Martens, and Tagliabue instruments, but since the war a new method has been introduced (I.P. 113) using a modified form of the Abel apparatus. Special credit is due to the Sunbury laboratories of the Anglo-Iranian Oil Company, for the development of this method, the results of which it is claimed do not differ appreciably from the minimum flash point of the material under equilibrium conditions of temperature and vapour pressure.

Adhesion.

It may naturally be asked whether the problem of adhesion—as, for example, to mineral aggregates—has received any attention. This was felt to be a matter which could be more properly dealt with by the British Standards Institution.

Emulsions.

Sub-Committee No. 7 has been fortunate in having two very active panels which have produced some good results in the past few years. These are the Bitumen Emulsion Panel and the Soil Stabilization Panel. The former has been working in co-operation with the Technical Sub-Committee of the Road Emulsions Association. It has recently developed I.P. 81—Coagulation of Bitumen on Storage of Bitumen Emulsions, and I.P. 91—Residue on Sieving of Bituminous Materials, both of which have been brought up from tentative to standard status in 1949.

In view of the complications of an emulsion system, the question of stability, and the effect of shear, with such phenomena as thixotropy and dilatancy to be considered, it will be appreciated that the determination of viscosity in absolute units has given rise to much discussion and controversy. As a result, the Panel had to abandon this, and, for standardization purposes, the use of the Engler viscometer has finally been recommended. The Panel and the Road Emulsion Association Committee referred to above are also continuing investigations in the development of practical setting and performance tests.

Soil Stabilization.

Special credit is due to the chairman and members of the Soil Stabilization Panel, which has tackled a new subject with such determination and success. It was concerned, naturally, only with bituminous stabilization, the primary aim of which is to provide mechanical stability, and resistance to such absorption of water as would reduce the stability. The Panel started its work in a systematic way, by first classifying all the tests put before it into groups in which the individual tests differed only in detail, and then considering each group in order to standardize the best all-round method.

The following are the more important of the tests developed :—

1. Preparation of soil mix.
2. Determination of moisture content.

3. The measurement of load-bearing capacity (L.B.C.) of compacted stabilized soil (two methods—cone penetration resistance and compression test).
4. The resistance to water absorption of specimens of stabilized soil (two methods—capillary water absorption and total immersion).
5. The determination of the bulk density of soil.
6. The measurement of frost resistance of compacted mixes.
7. The determination of the stabilizer content of mixes (two methods —cold and hot extraction).

Each of these is a specialized matter of its own, and it is not the intention here to discuss soil stabilization as such, but only to give some indication of the scope of the work upon which the Panel has been engaged.

A few words regarding some of the methods of approach to such standardization and the amount of work and co-operation involved may not be out of place here. Taking No. 6—frost resistance—for example, here contact was made with meteorological stations, data provided by the Building Research Station was considered, and a series of tests was put in hand using very special facilities offered by Rothamsted Experimental Station. In this large cylinders of naturally compacted soil set in the ground with pre-selected and adjustable water-tables could be kept under observation during periods of frost. For the determination of stabilizer content (No. 7) the methylene chloride road-binder extraction method of the Road Research Laboratory was suitably adapted, while one of the methods for water absorption (No. 4) was developed from a capillary water absorption test designed by the Shell laboratories to simulate the weathering conditions that occur in the field when the sub-grade is wet.

The Panel is working in the closest co-operation with the B.S.I. Sub-Committee RDE/9 (Soil Stabilization), for which it serves as a specialized panel of the B.S.I. dealing with bituminous stabilization. To illustrate the present position of this work, the following quotation from the chairman's latest report is given.

> *" It is hoped very soon to get a clear view of the trend of the work of this new Panel, and the Bituminous Panel will then be asked to undertake its share of the further experimental work. In the meantime it is hoped that various schemes of experimental soil stabilization in the field will be developed and the Panel has already made contacts which should lead to its being co-opted when there is a possibility of assisting with work in the field."*

It will be seen that the back of the very heavy task of the Soil Stabilization Panel has been largely broken, but the test methods involved have not yet been added to " Standard Methods."

Future Programme.

For the future—who can say? Perchance the present discussion may give a lead. In spite of the complexity of the constitution of bitumen, methods of broad chemical subdivision, such as those of O. G. Strieter into " resins," " oils," and " asphaltenes," have already received some con-

sideration, and co-operating laboratories have this matter under further investigation.

Durability is a word heard more often these days in bitumen-user circles in spite of the phenomenal life so frequently achieved by this relatively low-priced product in the many applications in which weather resistance and water-proofing are among the essential characteristics. Everyone will welcome the advent of the real durability performance test capable of accurate prediction of life in practice, but all who have had occasion to give serious thought to this most interesting aspect of bitumen testing will agree that it is a subject just about as complex as the material itself.

Discussion.

W. A. Partridge: I have served on some of the sub-committees for a long time, and can testify to the very careful work and effective co-operation of the various sub-committees and panels, which reflects great credit on the members.

However, this evening I want to start an argument. It seems to me that the I.P. Standardization sub-committees sometimes waste time in considering A.S.T.M. methods, modifying them, often in a very minor manner, and re-issuing them as I.P. methods. Why do we do this, when those methods are satisfactory, or apparently satisfactory, to our transatlantic friends? Is this due to our national caution, is it because we hate to leave loose ends, a characteristic not shared by our American friends, or is there really a definite need for modifying A.S.T.M. methods to fit our conditions?

I feel rather diffident about raising this matter, but it does seem to me to be important. We have a number of tests of local importance, such as char value—and, incidentally, asphaltene determination—all of which require considerable improvement, but which the Americans, for reasons best known to themselves, do not see fit to use. Therefore, let us confine ourselves to examining those methods of test which we need in the U.K., and let us use the A.S.T.M. methods just as the A.S.T.M. produce them. It must be remembered that the greater portion of world-wide petroleum trade is based on quality defined by A.S.T.M. methods, and I feel it would assist materially in ensuring co-operation between the I.P. and the A.S.T.M. if we could generally use the A.S.T.M. methods.

I have a few comments to make regarding the paper on the work of Sub-Committee No. 3. First, there is the char-value test: it is an admirable test, and tells us quite a lot about the quality of a burning oil; but I know from bitter experience that it takes far too long to carry out. A char-value test occupies 26 to 30 hr. It is a drag on a refinery laboratory, and when carrying out tests on a shipment of kerosine, at least 26 hr must elapse before a cargo can be passed for shipment. At a time when the turn-round of tankers is all-important, that is too long, and I ask Sub-Committee No. 3 to give some consideration to a shorter test which could be used as a refinery "go" and "not-go" gauge for char value.

With regard to the stability of tetra-ethyl lead in leaded fuels, although the results of the work were never published, this matter was very thoroughly thrashed out by the Chemical Sub-Committee of the Ministry of Aircraft

Production Main Fuel Committee during the war. I do not really think there is much necessity for test methods, because it was evident from that work that the factor involved is adequate refining treatment, which is covered by existing tests.

I know that the copper-strip tests have been popular for many years, but I would like to ask what they tell us. When we have done a corrosion test on polished pure copper, what does it tell us about the effect of an oil on copper or brass pipe which is coated with oxide or lacquer or other deposit when in service?

Finally, I would sound a note of warning, that we should avoid trying to improve the accuracy of our testing beyond the point at which we can sample large containers accurately; I am thinking in terms of the 4·7 million-gal storage tanks. If we improve our accuracy of testing beyond the accuracy with which we can sample, I think the industry as a whole will have many difficulties.

W. H. Thomas: I know that Mr Partridge has made some very trenchant remarks on these matters from time to time, and in my opinion with good reason.

Although, as I have explained, we are not entirely satisfied with the I.P. char-value test; it has actually been adopted by the A.S.T.M. and is detailed in Method D. 187–47T alongside the lamp which the A.S.T.M. have attempted to use all these years, with even poorer results than ours.

On the other hand, I agree entirely with Mr Partridge that the burning test is far too long It is one of the main difficulties of the man concerned with the refining of kerosine that he has to wait so very long to ascertain whether or not his product is satisfactory. He cannot avoid it; it is laid down in specifications. If the buyers require tests, the petroleum analyst has to carry them out, no matter what his opinion may be of those tests.

Again, I agree entirely with Mr Partridge that the work on tetra-ethyl lead stability was well done, and I consider that it could be incorporated, if necessary, as an I.P. method without further experimental work.

The work on the copper-strip test has been extremely interesting from the laboratory-investigation point of view. Here was a problem which seemed to be very difficult, and we felt we had accomplished quite a step forward in being able to analyse a film on a piece of copper. When it was found that part of the film was not due to sulphur at all, but to oxygen, we wondered whether the copper-strip test was of any real value. As an indicator of the presence of corrosive sulphur, on the other hand, the copper-strip test is called for in specifications, but many suppliers would be glad to get rid of the test.

The problem of relating accuracy of testing with accuracy of sampling is a very real one indeed. We hope that in the coming years, in working out these problems, the statistician who tells us the repeatability and reproducibility of our results, will give his views far more frequently and insistently than formerly, because only he can tell us where we are going wrong and where we are striving for accuracies which we cannot achieve.

Mr Partridge: We are told by Mr Thomas that the copper-strip test is included in specifications. I suggest that, if the I.P. drops that test, the

people who draw up specifications might be induced to dispense with it also.

MRS KNIGHT (Road Research Laboratory) with the agreement of Dr Lee: The new definition of *bitumen* put forward here raises several questions.

Presumably asphalt will now be definied as: *Natural or mechanical mixtures in which bitumen is associated with inert mineral matter.*

As no limits are given for the *size* of the mineral matter, it follows that any mixture ranging from a sand carpet to a bitumen macadam can be termed as asphalt. Is this the correct interpretation of the term asphalt?

Bitumen. The term "semi-solid" appears to be unsatisfactory, as we do not think it can be defined; further, liquids are not recognized as being bitumens. To say that bitumen is derived from petroleum and may occur naturally is perhaps committing ourselves unnecessarily on the question of the origin of naturally occurring bitumens.

The following definition is suggested:—

> Bitumen. *A black or dark brown material, liquid, viscous, or solid, derived from petroleum or occurring naturally, showing a marked reduction in consistency when heated, having adhesive properties, composed essentially of hydrocarbons and being soluble or substantially soluble in carbon disulphide.*

It would be advantageous if bitumen were admitted as an adjective, to be used in a more restricted sense than the word bituminous.

> Bituminous. *Resembling or having physical properties similar to those of bitumen or containing substances having these properties. This broad definition would include substances containing tar.* Bitumen (adj.). *Containing bitumen (as, for instance, bitumen macadam).*

C. F. JACKSON: With regard to the point concerning the definition of "asphalt" and the size of the matter in it, I consider that when mineral matter is present with bitumen, the mixture is "asphalt," irrespective of the amount and the size of the mineral matter present. The definition of "semi-solid" is a matter about which there could be a lot of discussion; I do not think I can say very much about it now.

I do not quite understand Mrs Knight's point about bitumen being derived from petroleum. The definition of "bitumen" which I have given in the first part of the paper as being the last redrafting does not restrict bitumen to being a derivative of petroleum. It is stated in the second half of the definition that bitumens may occur naturally.

MRS KNIGHT: Unfortunately that is stated only in the second part. It is stated quite clearly in the first part that bitumen is derived from petroleum. I disagree only with the order in which it is put.

MR JACKSON: I also think the question of solubility should be included, and I am most grateful for your suggestions; they are very valuable, just the sort of thing we wanted. The suggested definitions will be considered by Sub-Committee No. 7 at the first opportunity.

I have received a letter from Dr Bernard Knight and he puts forward some points. He states :—

> "In my view it is high time that a test for the adhesion of binders to aggregates be introduced and standardized, and I see no reason why this should not be done forthwith.
>
> "I myself have used the Bottle Test for nearly ten years and I suggest that it gives a very good approximate idea of the degree of adhesion of binder to aggregate. Carried out in the laboratory with distilled water at 40° C for 4 hours on ⅜-in chippings, I have found it simple and useful."

I did say in the paper that Sub-Committee No. 7 had decided, when we had discussed this matter, that it was one for the B.S.I., being not by any means primarily concerned with the bituminous part, but perhaps more with the mineral aggregate part, and particularly in view of the great variability of mineral aggregate as regards the property under consideration by comparison with bitumen, and the much larger quantities of mineral aggregate. But inasmuch as the matter has been raised, it is only right that it should be considered again by Sub-Committee No. 7, and I shall be glad to put it forward in the usual way.

Then Dr Knight states :—

> "Operators must be trained to recognize adsorption of oily constituents of binder by porous aggregates, and I suggest that a series of type photographs, as developed by the Road Research Laboratory in published work on this subject by Dr A. R. Lee and his associates, could be included in a British standard, as has already been done in the case of particle shape and surface texture."

Unfortunately, although I have looked, I have not been able to find the particular article mentioned. Perhaps someone is here from the Road Research Laboratory and would like to say something about it. But again I would not have thought that the measurement of absorption, or adsorption, or both, was so much concerned with the testing of the bitumen as with the testing of the aggregate. It is the stone which is bad and which sometimes absorbs and/or adsorbs undue quantities of bitumen, or oil from the bitumen. However, whether or not the question should be decided by the I.P., is a matter that we can put to Sub-Committee No. 7.

MRS KNIGHT : I am in difficulties. I rather think there is a mistake regarding the publication by Dr Lee, for we have not been able to find the article mentioned. I must support Mr Jackson.

MR JACKSON : I have also received a letter concerning nomenclature from Dr Percy E. Spielman. He does not agree with my statement to the effect that our practice in defining these materials differs fundamentally from American usage. I have given in the paper three so-called international definitions. The definition of "*bitumen*" is word-for-word the same as that of the A.S.T.M. The definitions of "*asphaltic bitumen*" and "*asphalt*" are quite different from those of the A.S.T.M., for, as I have stated, the A.S.T.M. define "asphalt" as the petroleum product, substantially soluble, which we know as "bitumen." I still think that our definitions "differ fundamentally from American usage, which employs the word 'asphalt' to mean what is commonly referred to in the U.K. as 'bitumen.'" I regret, therefore, that I cannot agree with Dr Spielman on that point.

Dr Speilman also says that the " bitumen " definition was adopted by the International Committee from America unchanged, and from it to the B.S.I. He has always thought it a very bad definition. He also states that " asphaltic bitumen " indicated that bitumen suitable for the manufacture of asphalt. That is certainly new to me; I have not heard it put that way before.

The final point which Dr Spielman raises is rather important. He thinks it is not the function of the I.P. to pass the finally approved definitions to the B.S.I. for their benefit, and to the Permanent International Association of Road Congresses. I do not know where he gets that idea; I quite thought that the I.P. should have the job of defining petroleum products and passing the definitions to the B.S.I.

W. Pohl: With regard to the inter-relation of the I.P. and the B.S.I. in the matter of test methods, I do not appreciate the argument that an adhesion test should not be dealt with by the I.P., but by the B.S.I. on the grounds that there is more stone than bitumen in the mixture. I do not think this is justified. It is not legitimate to say that, because there is more of another material than of petroleum in a mixture, it is not a matter to be dealt with by the I.P.

My own impression was that, in the main, the I.P. should deal with any methods concerning any properties of petroleum products in relation to themselves or when they are mixed with something else, and that the B.S.I. is more concerned with specifications and the use of those methods. I may be wrong, but this seems to be a useful line of distinction. When the B.S.I. want a method, and if there is an I.P. method, they use it.

May I join issue with Mr Thomas on the question of the copper-strip test? It is said that Sub-Committee No. 3 went into it because it is specified by users. I am not really worried so much about the copper-strip test itself; it is the attitude that I think is wrong. Somebody in the dim and distant past has invented a test for measuring a property which was thought to be important. Bitumen, for instance, is soft or hard, and the penetrometer was invented. We go on standardizing methods without asking ourselves whether the figures obtained have a relation to practice. Sometimes it may be better to forget about existing methods, and to ask ourselves what it is that we really want to measure; and when we know what we want to measure we should consider the best way in which to measure it and to obtain a result which will be of some use.

Sometimes also it seems to me that we go to absurd lengths in making I.P. testing methods more extensive or more accurate. Are we justified in making a very pretty and elaborate test for measuring sulphur in a film? A speaker has already suggested that sometimes we go to extreme limits of accuracy which have no value, in that the accuracy of our testing methods is beyond the accuracy of sampling. In connexion with fuel, a test was invented to give an idea as to whether or not we had too much diluent in the engine. The original idea was to decide whether something of the order of 0 to 5 per cent or 10 or 15 per cent or so was present. Now attempts are being made to enable the method to tell us whether it is, say, 0·35 or 1·69 per cent. This is all very well from the viewpoint of accuracy, but does it really mean anything?

THE PRESIDENT: The copper-strip test was developed in much the same way as were practically all the tests that we have discussed during the last thirty odd years. It came into being in Mexico at a time when trouble was experienced with carburettors. It was one of our own members, Mr Lomax, who suggested trying out the spirit on some copper in order to ascertain whether it was likely to corrode carburettors.

I think that, if you examine the origin of practically every test we have got, you will find that they arose from very simple beginnings such as that.

VOTE OF THANKS.

V. BISKE, proposing the thanks of the meeting and of the Institute to the authors of the papers, said: Much has been written recently in the technical literature regarding the growing importance of analytical chemistry and of the improvement which should accrue to the status of the analyst. In the examination of petroleum products we are largely concerned with analysis, and there is no doubt that, in our industry, full weight is attached to this branch of technology.

Like most modern developments oil testing is becoming more and more complex, and it is probably correct to say that to-day, there may be less scope for the operator who does a test and more responsibility resting on the persons drawing up test procedures. Some of the modern automatic testing methods that are coming into increasing use, particularly in the U.S., indicate the greater importance of the sound design of the test method, compared with the carrying out of the test itself, as for example where a sample is put into a distillation cabinet and the answer obtained on a ticket in 40 min.

The international aspect of this problem of tests and their standardization cannot, I feel, be too strongly stressed. A previous speaker has mentioned the wasted effort involved in modifying A.S.T.M. tests and adopting the modified versions as I.P. standards. What is perhaps even more important is the multiplicity of test methods existing in various countries. If one looks at the list of foreign test methods published by the B.S.I. one finds that a large number of countries—I will not mention any country by name, but the populations of some of them are about equal to the populations of Birmingham, Manchester, or any one of our big cities—are developing standards and tests for this and that, which seems quite unnecessary and superfluous; the sooner the methods used in the larger and more important countries are universally recognized the better. We want methods that have been agreed internationally by experts in the various fields.

The copper-strip test has been the subject of much comment this evening. I have read with considerable interest the remarks of Mr Thomas concerning making this test quantitative, and I feel that such a course would tend to stop arguments in laboratories, which inevitably arise when a test of this type gives a result on the border-line; if we can get a quantitative figure for all standardizing work it will be of greater advantage. Unfortunately, however, there does not appear to be any hope of rationalizing tests for factors such as smell and taste, where the sales side can tell the laboratory that their opinion is as good as anyone else's!

The standardizing of tests for petroleum and its products is a field in

which the Institute is gaining prestige and recognition, which is all to the good, as well as leading to a higher level of accuracy in such work.

The popularity of this meeting, as evidenced by the large attendance and the fact that the discussion had to be closed on account of the time factor, should be of encouragement to the various sub-committees concerned, showing that their work is being followed with very considerable interest and attention. I am glad to propose a vote of thanks to our team of four lecturers for having given us an extremely interesting evening.

(The vote of thanks was accorded with acclamation and the meeting closed.)

Written Discussion.

D. C. Broome: After quoting the international standard definitions for bitumen, asphaltic bitumen, and asphalt Mr Jackson goes on to quote the latest definition for bitumen agreed by Sub-Committee No. 7 in co-operation with Sub-Committee No. 11, and states that: "This will then presumably be the definition officially sponsored by the I.P. and recommended to the B.S.I. and to the Permanent International Association of Road Congresses."

I am, however, of the opinion that the latest definition as drawn up by Sub-Committees No. 7 and No. 11 would not be of any serious interest to the B.S.I. or the Permanent International Congress.

The terms of reference to Sub-Committee No. 11 (October 1943) were that definitions "should be couched in as simple language as possible in order that the non-technical reader could consult the glossary and derive, it was hoped, a real benefit from it." These terms of reference, together with the subsequent work of the Sub-Committee have, to my mind, clearly been along the lines of defining the various terms in simple language so that these could be understood by "the man in the street."

Whilst such glossary terms will be of interest and value, this is quite a different matter from the formulation of standard definitions. These latter should be drawn up in a strictly scientific manner, and should be so carefully worded that they will be sound from a legal as well as from a scientific point of view. This means that they will not of necessity be simple definitions, neither will they of necessity be readily understandable by "the man in the street." They are, however, of vital importance, and I hope that it may be possible for these two types of definitions to be clearly distinguished from one another, and I trust that it will also be possible for the Institute to take a hand in the bringing up to date of the international definitions for bitumen and allied terms which were originally agreed in 1926.

With regard to the adhesion test, it was suggested by Dr Knight that not only was such a test desirable but also that it would be a very simple matter to formulate such a test. I would, however, suggest that the position is, in fact, not nearly so simple as was indicated by Dr Knight.

As was mentioned in Mr Jackson's paper, the matter was referred to the B.S.I., and it would seem to be of some significance that the B.S.I. Technical Sub-Committee, to which the matter was referred, were of the opinion that there is no test at present available which will give a reliable indication of adhesion between binder and stone under road conditions.

This committee further considered that inclusion of any of the available tests in a British standard would be unsatisfactory at the present time, since the tests might be used unfairly, and the results obtained would in any event be liable to misinterpretation.

MR JACKSON wrote: I am rather surprised that Mr Broome is of the opinion that the latest definition drawn up by Sub-Committees Nos. 7 and 11 would not be of any interest to the B.S.I. or to the Permanent International Association of Road Congresses. Whether we call this a definition or a glossary term and in spite of the simplicity of language, a great deal of trouble was taken in an effort to arrive at a technically sound result. Thus "hydrocarbon" was replaced by "composed predominantly of hydrogen and carbon," because it was pointed out that some bitumens contain 6 per cent or more of combined sulphur, and that this percentage may, in some cases, be equivalent to a ½ to 1 mol of sulphur per mol of bitumen. The trouble with the existing official definitions is not that they are written in difficult technical language but, in my opinion, that they do not make sense anyway. Thus, "bitumen" can be an invisible gas, a water-white liquid, or a solid of any hue. Surely a simple, accurate term is far preferable to this!

For the rest I am very much in agreement with Mr Broome's remarks, and the additional point which he makes regarding the adhesion test is, I think, very apt and important.

VERNON L. SMITH: In formulating tests for controlling products, do the various committees consider the time factor?

It does seem that there is a general tendency to evaluate down to very minute limits of accuracy, without any regard to the time taken. I should like to raise this question re the work of Sub-Committee 6, Lubricants.

Over the last ten years, the introduction of various chemical additives to lubricating oils has greatly increased the work of the laboratory, and particularly those which are connected with the control of operations on blending and production of lubricants. Time is a very important factor on these plants, and present tests elaborated for use do not in any way take this fact into consideration. I should like to quote one example in this connexion, namely the sulphated-ash method for determining the amount of chemical additive in detergent H.D. oils (I.P.—5/42 Method B).

This test, following the instructions laid down in the I.P. Method Book, takes approximately 8 hr to complete, and whilst, no doubt, it is very suitable from a committee's point of view does represent a considerable hindrance in plant operations.

Is it possible to consider the introduction of tests for specialized lubricants which whilst giving a slightly less degree of accuracy could be utilized by plant laboratories for general control work where time is the limiting factor?

R. E. J. WHITE: I was interested in the remarks of Mr Thomas in dealing with Sub-Committee No. 3 in connexion with spectroscopy. It appeared that the possibilities of the method as a means of providing a suitable standard test were only being considered, but the proposition for the setting up of the Spectroscopy Panel seemed very promising.

Mr Thomas expressed doubts as to whether this type of equipment could be standardized. I would venture to say that of all analytical apparatus shown in Mr Thomas's illustrations the spectroscopic instrument should lend itself to standardization more than any other. This is particularly so, since there are very few firms making the equipment on either side of the Atlantic.

The method shows certain very great advantages. Particularly :—

(*a*) Saving of time in carrying out the analysis.

(*b*) The apparatus can be operated by reasonably competent laboratory assistants.

(*c*) It is especially applicable to hydrocarbon liquid mixtures of close boiling point, which present difficulty in the case of fractional distillation.

(*d*) The method does not destroy the sample, and the analysis can therefore be repeated as many times as desired on the same sample.

If the Spectroscopy Panel is formed some or all of the British manufacturers of this equipment would probably be very interested and willing to assist.

W. H. Thomas (in reply to written discussion) : Comments by Mr White on the possibility of developing a standard method of test to cover spectroscopic analysis are both helpful and instructive.

We are, of course, aware that the A.S.T.M. has already proposed a method of test for benzine and toluene contents by ultra-violet spectrometry and that a similar write-up could be devised for the analysis of the lighter paraffin hydrocarbons by infra-red techniques.

The possibility of standardizing the equipment used for these purposes is, you will agree, a much more difficult matter, and incidentally, it is to be noted that the A.S.T.M. merely specifies the general apparatus requirements with a note-reference to the Beckman quartz spectrophotometer.

It is hoped that in the near future the Gases and Light Distillates Sub-Committee will be able to report some progress in the matter of the formation of a Spectroscopic Analysis Panel. In the meantime, advice and opinion is being sought from the Spectroscopic Panel of the Hydrocarbon Research Group.

PUMPABILITY, RHEOLOGICAL PROPERTIES, AND VISCOMETRY OF DRILLING FLUIDS.

By H. VAN OLPHEN.*

SUMMARY.

From an analysis of mud flow through the rotary mud circuit the rheological information required for the prediction of pressure losses in the various parts of the circuit is formulated. A suitable viscometer is developed, and some results are presented.

INTRODUCTION.

WHEN oil wells were drilled to shallow depths and slush pumps were driven with steam power, the pumpability of the mud was never a very serious problem. In present-day deep-drilling operations, however, and where the pumps are driven by diesel engines, pumping pressures are more critical. Consequently, increasing attention is being devoted to the pumpability of muds, and to their rheological characteristics, which affect pumping pressures. Although much thought has been given to both pumpability and rheology in literature, their relation has not been settled either in theory or in practice.

This is mainly due to the lack of appropriate viscometers to supply the required rheological information. The usual apparatus like MacMichael, Stormer, Marsh funnel, etc., are arbitrary instruments in which the flow pattern is ill defined, and although the results may be used in a relative way in daily routine control of mud samples, no basic data are obtained for use in pressure-loss calculations. Therefore, the need was felt for a viscometer—preferably a routine-type instrument—which would supply these fundamental data.

In the present survey the relation between the rheological characteristics of muds and their pumpability is discussed first. The mud flow in the rotary circuit is analysed and, on the strength of this analysis, the fundamental rheological information required for pressure-loss calculations is formulated. The development of a suitable viscometer is then described, and, finally, some data on different types of mud are presented.

The formulas given are based on the c.g.s. system therefore the acceleration of gravity does not enter into them where it has no physical significance. Pressure losses expressed in dynes/cm^2 may easily be converted into p.s.i. or atmospheres by multiplying by $14{\cdot}5 \times 10^{-4}$ or $0{\cdot}986 \times 10^{-6}$, respectively.

The following rheological definitions and symbols are used :—

τ : the shearing stress applied (dynes/cm^2).
D : the rate of shear (sec.$^{-1}$).
Newtonian flow : $\tau = \eta . D$ where η = the viscosity (dyne sec/cm^2 or poise).
Ideal plastic flow : $(\tau - \tau_0) = nD$,

where τ_0 = the yield stress, the minimum stress causing flow, and n the "differential viscosity." If ideal plastic flow is only approximated the extrapolated straight part of the $\tau - D$ curve intersects the τ-ordinate at τ_B, called the "Bingham yield stress,"

* Koninklijke/Shell Laboratorium-Amsterdam.

which is larger than the true yield stress τ_0 of the system. "Thixotropy" or isothermal sol–gel transition relates to the dependence of the τ–D curve on the history of the system. On agitation, the yield stress or the viscosity or both decrease, but the original values are restored after a period of rest. Thixotropy therefore should always be related with time.

All this applies to laminar or streamline flow, where the streamlines are parallel.

With increasing fluid velocities the ratio of inertia and frictional forces increases and, beyond a certain critical velocity, results in turbulent flow. This critical speed is calculated from the critical value of the Reynolds number, which is dependent on the shape of the vessel or tube through which the fluid flows.

Analysis of Mud Flow with Respect to the Pressure Losses in the Rotary Mud Circuit.

Pressure losses in the mud circuit occur in the surface connexions, the drill pipe, the tool joints, the bit nozzles, the bottom of the hole where the mud stream is reversed, and the annular space between drill pipe and bore hole or casing.*

A. The pressure-loss formulas for the circulation of Newtonian liquids ($\tau = \eta \,.\, D$) can be summarized as :—

(i) *Flow through the Drill Pipe*. The pressure losses for laminar flow are governed by Poiseuille's law :—

$$P = \frac{8L\eta v}{R^2} = \frac{8L\eta Q}{\pi R^4}$$

where L and R are the length and radius of the drill pipe, respectively,

v the average linear speed of the fluid $= \dfrac{Q}{\pi R^2}$,

Q the volume rate of flow.

The maximum shearing stress at the wall of the pipe is $\tau_R = \dfrac{PR}{2L}$, and the maximum rate of shear $D_R = \dfrac{PR}{2L\eta} = \dfrac{4Q}{\pi R^3} = \dfrac{4v}{R}$.

Flow is laminar up to the critical value of the Reynolds number $Re = \dfrac{2Rv\rho}{\eta} = \dfrac{2Q\rho}{\pi\eta R}$, where ρ = the density of the fluid.

The critical value is dependent on the shape of the ends of the tube, and may be assumed to be *ca* 2000 in this case.

As soon as the critical Reynolds number is exceeded flow becomes turbulent, and then the pressure losses are given by the Fanning–Darcy law :—

$$P = f\frac{L\rho v^2}{R} = f\frac{L\rho Q^2}{\pi^2 R^5}$$

where f is the "friction factor," an empirical constant, which varies with the value of the Reynolds number. The relation of f and Re depends on the roughness of the tube. According to Blasius $f = 0{\cdot}079\ Re^{-1/4}$ for

* The slight difference of the specific gravities of the mud in drill pipe and annulus, due to the presence of the drill cuttings in the annulus, requires a small additional pumping pressure.

Reynolds numbers between 2000 and 100,000, and the pressure losses become proportional to :—

$$P \sim \frac{L.v^{1.75}}{R^{1.25}} \cdot \rho 0{\cdot}75 \eta 0{\cdot}25.$$

At still higher Reynolds numbers, which are quite common in mud circulation, f becomes gradually less dependent on the viscosity and directly

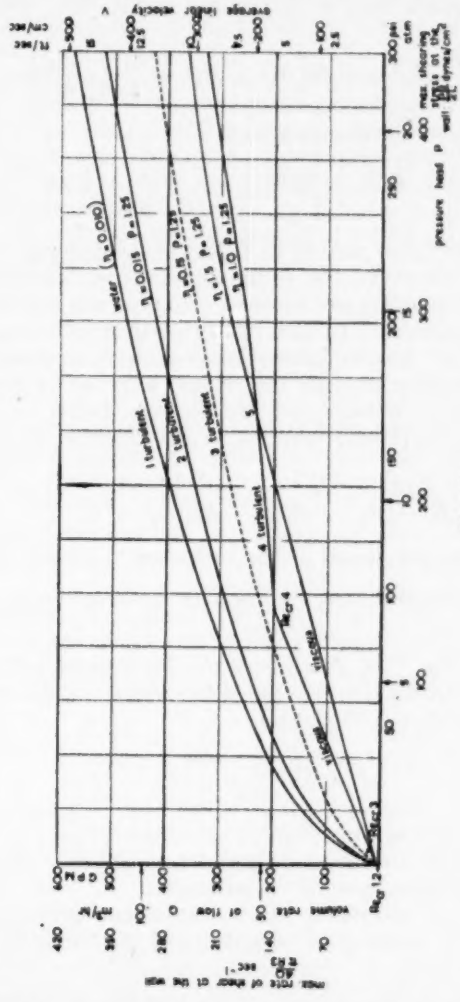

FIG. 1A.
FLOW OF NEWTONIAN LIQUIDS THROUGH 3000 FT OF 4½-IN O.D. DRILL PIPE.
Pressure head as a function of volume rate of flow (calculated).

proportional to the density. This may result in high-pressure requirements when pumping barytes-laden muds into deep wells.

The pressure losses P as a function of the rate of circulation Q for some Newtonian liquids are presented in Fig. 1*a*. The data are calculated for

flow through 3000 ft of 4½ in O.D. drill pipe. For low-viscosity fluids parabolic turbulent-flow curves ($P \sim Q^2$) are obtained at any practical rate or circulation (Curves 1, 2, 3). Flow will be laminar up to practical rates of circulation in the case of high-viscosity fluids (Curves 4, 5). The shift towards higher pressures of Curve 2 with respect to the curve for water (Curve 1) is mainly due to the high specific gravity (1·25).

(ii) *Flow through the Annulus.* For laminar flow the equivalent of the Poiseuille equation reads ($2R_1$ = I.D. of the casing, $2R_2$ = O.D. of the drill pipe) :—

$$Q = \frac{\pi P}{8L\eta_i}(R_1^2 - R_2^2)\left(R_1^2 + R_2^2 - \frac{R_1^2 - R_2^2}{\ln R_1/R_2}\right).$$

The Reynolds number for the annulus is

$$Re = \frac{2(R_1 - R_2)v\rho}{\eta_i} = \frac{2\rho Q}{\eta_i \pi(R_1 + R_2)}.$$

Theoretically, therefore, flow may be turbulent in the drill pipe at a certain volume rate of flow where the flow in the annulus is still laminar. However, in practice, the swinging and rotating drill pipe will certainly disturb laminar flow in the annulus. In case of laminar flow, the eccentricity of the drill pipe results in smaller pressure losses than those calculated.

If the Reynolds number exceeds the critical value of *ca* 2000, flow in the annulus becomes turbulent, and the pressure losses are calculated according to the Fanning–Darcy equation for the annulus :—

$$P = f\frac{L\rho v^2}{R_1 - R_2} = f\frac{L\rho Q^2}{\pi^2(R_1 - R_2)(R_1^2 - R_2^2)^2}.$$

Theoretically, the pressure losses in the turbulent range are independent of the eccentricity of the drill pipe, the mean hydraulic radius $m = \dfrac{R_1 - R_2}{2}$ remaining the same.

(iii) *Flow through the Tool Joints and the Bit Nozzles.* The pressure losses on passing a stricture, where the difference in height is negligible, are derived from the Bernouilli theorem :—

$$P = \frac{\frac{1}{2}\rho Q^2(1 - \beta^4)}{c^2 A^2}$$

where :—

- β is the ratio of the diameters of the stricture and the drill pipe.
- A is the cross-sectional area of the strictures.
- c is an empirical constant, the "contraction coefficient," which depends on the shape of the stricture and the Reynolds number in the stricture.

For the bit nozzles c is found to be 0·8, and β^4 may be neglected, being small compared with 1.

For tool joints c is usually taken to be equal to 1·0, and it is found that about 70 per cent of the total pressure loss is recovered after passing the tool joint. β is dependent on the type of tool joints. In the regular tool

joints $\beta = 0{\cdot}55$ to $0{\cdot}60$, and consequently the pressure losses are rather large, sometimes of the same order of magnitude as those for the drill pipe itself. In the full-hole type ($\beta = 0{\cdot}82$ to $0{\cdot}88$) the pressure losses are comparatively small, and they are negligible in internal flush joints ($\beta = 0{\cdot}97 - 0{\cdot}98$).

(iv) Additional pressure losses occur in the surface connexions and at the bottom of the hole. The former, which are comparatively small, may be roughly calculated from the number of bends, fittings, and valves, which are to be expressed in equivalent lengths according to the engineering handbooks.

The pressure loss at the bottom of the hole may be expected not to exceed $\frac{1}{2}\rho v_a^2$, where v_a is the average linear velocity in the annulus.

As to the relative magnitude of the pressure losses in the various parts of the system, it is found that the losses in the annulus are usually small in comparison with those in the drill pipe. The losses in the bit nozzles become very high for small nozzles. As an example, the following pressure losses (p.s.i.) are obtained when circulating a 1·24 sp. gr. mud at a rate of circulation of 400 g.p.m. :—

Surface connexions : 50.	Two $\frac{5}{8}$ in bit nozzles : 570
3000 ft $4\frac{1}{2}$ in O.D. drill pipe I.F. : 175.	Two $1\frac{1}{8}$ in bit nozzles : 55
3000 ft annulus (8·83 in I.D. casing) : 12.	

It may be concluded that the basic formulas for the pressure loss–flow relations are sufficiently known in the case of Newtonian liquids or suspensions which behave very nearly like Newtonian liquids.

If, however, the system has a yield stress the problem becomes more complicated.

B. For simplicity the flow of suspensions which obey the equation of ideal plastic flow $\tau - \tau_0 = n.D.$ or its approximation $\tau - \tau_B = n.D.$ is discussed.

In the regions where laminar flow may exist, viz., in the drill pipe and in the annulus, the pressure losses may be calculated from the Bingham–Buckingham equation.

At practical rates of flow in the drill pipe this equation reads :—

$$Q = \frac{\pi R^4}{8Ln}(P - \tfrac{4}{3}p_0), \text{ where } p_0 = \frac{2L\tau_0}{R} \text{ or } \frac{2L\tau_B}{R}$$

which is represented by the asymptote of the steep part of the curves in Fig. 1*b*, whereas, for the annulus, the following rather complicated formula is obtained :—

$$Q = \frac{\pi P}{8Ln}(R_1^2 - R_2^2)\left(R_1^2 + R_2^2 - \frac{R_1^2 - R_2^2}{1nR_1/R_2}\right) - \frac{1}{n}\pi\tau_0(R_1 - R_2)\left(\tfrac{1}{3}(R_1^2 + R_1R_2 + R_1^2) - \frac{R_1^2 - R_2^2}{1nR_1/R_2}\right).$$

For turbulent flow in bit nozzles and tool joints or—at high rates of circulation—in drill pipe and annulus, formulas relating the pressure losses with both n and τ_B are not known with certainty. Although for pipe flow a parabolic relation between pressure loss and rate of circulation

is found experimentally (Fig. 1*b*), the literature data cannot be correlated with reliable data for both n and τ_B.

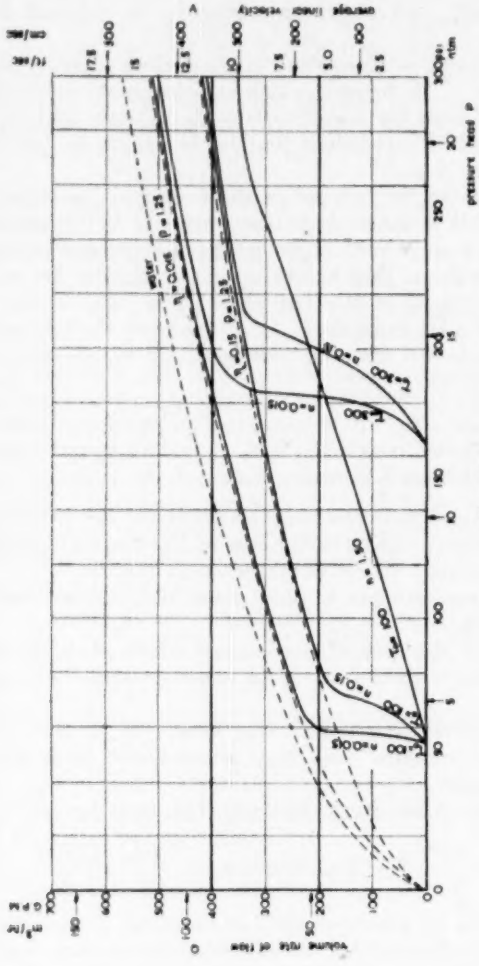

FIG. 1B.
FLOW OF IDEAL PLASTIC FLUIDS THROUGH 3000 FT OF 4½-IN O.D. DRILL PIPE.
Pressure head as a function of volume rate of flow (calculated).

Pressure losses may again be expressed in a Fanning–Darcy equation $P = f\frac{L\rho V^2}{R}$. The friction factor f should again be related with the Reynolds number, but the problem is how to define a Reynolds number for these systems.

A correct mathematical deduction of a Reynolds number as a function of n and τ_0 from the Bingham–Buckingham equation is given by McMillen.[2] The critical value of the Reynolds number according to his formulation is again around 2000 for the systems investigated by McMillen. How-

ever, for many systems reported in the literature which approximate ideal plastic flow a much lower critical value results from McMillen's equation.

A critical value of around 2000 is found for many data in literature if a Reynolds number is based on an apparent viscosity containing both n and τ_0, according to Binder and Busher.[3] The transition points of laminar to turbulent flow indicated in Fig. 1*b* are calculated according to their definition. However, these authors do not relate pressure losses with this Reynolds number.

Dunn, Nuss, and Beck,[1] who were the first to relate pressure losses in the mud circuit with viscometric data, correlate the turbulent-flow pressure losses with n only, thus neglecting the effect of the yield stress. This does not seem correct, although for a number of muds tested in the field pressure, losses could be calculated according to their procedure which agree with those measured to within ± 10 per cent. As, however, for various systems reported in the literature, the yield stress certainly appears to affect the turbulent-flow-pressure losses in pipes and strictures, it is still questionable whether the yield stress may be neglected in the case of turbulent flow of drilling fluids. Further data will be required to settle this question.

Consequence for Mud Viscometry.

Turning to the discussion of the significance of rheological data for the practical pumping problem the above considerations may be summarized as follows :—

The flow of low-viscosity muds without a yield stress is turbulent under all circumstances throughout the mud circuit. As the pressure losses vary only slightly with the viscosity (given by the friction factor–Reynolds number relation) no accurate determination of the viscosity is required in this case, and a rough estimate will suffice.

The flow of high viscosity muds without a yield stress, however, may be laminar in drill pipe and annulus up to practical rates of flow. In this case the viscosity should be determined accurately, the pressure losses being proportional to the viscosity. As the mud suspensions may not be truly Newtonian, the viscosity should be determined under the conditions prevailing in practice, *i.e.*, at the rates of shear occurring in drill pipe and annulus (which may be estimated to cover the range of 100 to 400 sec^{-1}) and after subjecting the mud to a pretreatment, simulating the amount of shear in pumps and bit nozzles. This shearing action will affect the viscosity in drill pipe and annulus respectively because of the thixotropic behaviour of most muds. The proper pretreatment has still to be standardized on the strength of comparative experiments with samples taken from various parts of the mud circuit and with samples subjected to agitation in laboratory stirrers.

Also for muds having a yield stress flow may be laminar up to practical rates of flow in the drill pipe and annulus; then the pressure losses are determined by the position and slope of the curve in the P–Q diagram or, in other words, by the Bingham yield stress and n. It would be desirable, therefore, to determine a few points of the stress-rate of shear curve in the shear region of 100 to 400 sec^{-1} and to extrapolate the curve in order to

find the Bingham yield stress. Again, the muds should be subjected to a proper treatment.

In practice there are still some other factors affecting the rheological properties, viz., temperature and pressure. The former is easily taken into

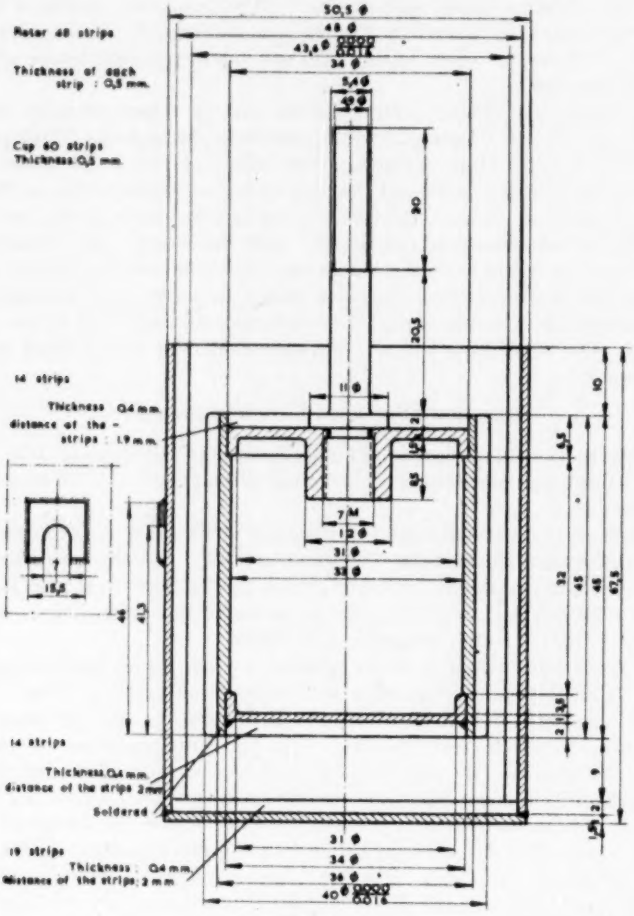

FIG. 3.

MODIFIED STORMER CUP AND ROTOR.

The upper and lower surfaces of the rotor and the bottom of the cup have parallel strips.

account by carrying out the determinations in a bath of the required temperature. From an experimental point of view, the high pressure would be an inconvenience. It is believed, however, that the pressures occurring in practice will not affect the rheological behaviour appreciably. It may be expected therefore that the effect may be neglected.

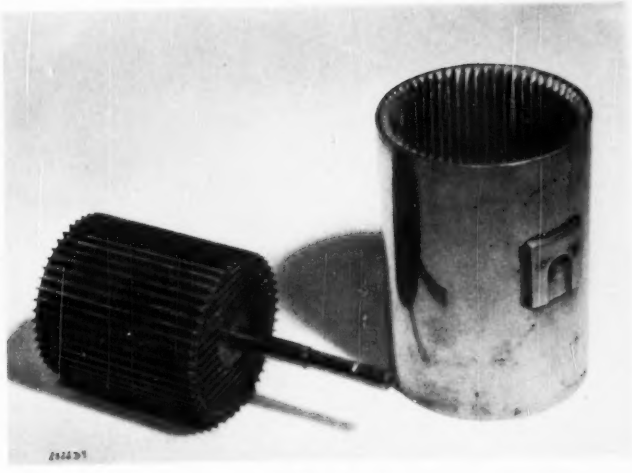

FIG. 2.

MODIFIED CUP AND ROTOR FOR STORMER VISCOMETER.

[*To face p.* 230.

A Modified Stormer Viscometer.

A rotational-cylinder-type viscometer seemed to be the most suitable type for determining the viscosity or the stress-rate of shear diagram of suspensions under the conditions which have been formulated in the preceding chapter. Clearance between the cylinders should be small in order to keep the rate of shear between narrow limits. The dimensions are further dictated by the range of rates of shear at which the apparatus should operate, *e.g.*, 100 to 400 sec^{-1}.

In addition, due consideration should be given to the possibility of slip of the suspensions at the surface of the cylinders, which would obscure the determinations. Parallel experiments with smooth cylinders and those provided with anti-slip strips have shown that in most cases both assemblies yield identical results. However, in some cases—particularly emulsion-base muds and flocculated clay-base muds—viscosity and yield-stress values are found which are 30 to 40 per cent low. Therefore, though slip is certainly not of common occurrence, the provision of anti-slip strips will ensure the general applicability of the instrument.

A suitable cup and rotor have been developed along these lines, and they have been adapted to the well-known Stormer viscometer, an apparatus which is already in common use for the testing of muds. The original Stormer cup and rotor did not comply with the above requirements, as wide variations of the rate of shear are encountered between cup and rotor as well as inside the hollow rotor. Further, the design is rather favourable for the onset of turbulence which limits the applicability to low rates of shear. The usual 600-r.p.m. Stormer viscosity is certainly measured in the turbulent range, and cannot therefore be converted into fundamental data. Finally, slip is not avoided. The apparatus itself, however, is of reasonable mechanical design, and the modification can be restricted to a modification of the cup and rotor. Fig. 2 shows a photograph of the new cup and rotor, Fig. 3 the construction and dimensions.

After calibration and calculation of the apparatus constants the stress-rate of shear curves of a number of muds have been measured after subjecting the muds to some tentative pretreatment, which has, however, yet to be standardized on the strength of practical experience.

Results Obtained with the Modified Stormer Viscometer.

The best procedure to determine the stress-rate of shear diagrams, which are derived from the driving weight–r.p.m. diagrams, is to use a fresh sample for the determination of each point of the curve after submitting the sample to the required pretreatment. If, alternatively, a complete curve is determined on one sample only, thixotropic changes during each run may be superimposed on the true curve. If, after the pretreatment, the mud stiffens only slowly, both procedures yield practically identical results. In many cases, therefore, the latter method, being less elaborate, is preferred, particularly in routine work.

All muds tested appeared to approximate very closely ideal plastic behaviour or Newtonian flow respectively. Some examples, demonstrating the general shape of the curves obtained, are collected in Figs. 4 and 5.

At high rates of shear the onset of turbulence in the viscometer is apparent from an upward bend of the curves. Although turbulence is a limiting factor in the viscometer, the shear regions of laminar flow in our instrument fully cover the laminar flow regions of actual practice.

In Table I a number of test data are collected, from which the following general rules are concluded : the differential viscosity of clay–water-base muds generally varies between 5 and 25 c.p. Oil-base and emulsion-base muds usually show higher values : between 35 and 100 c.p.

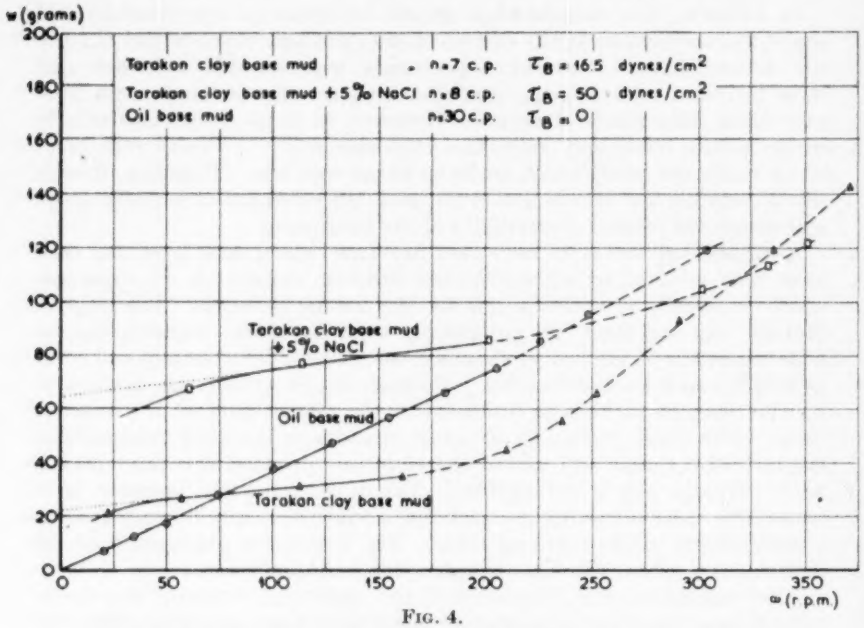

FIG. 4.

DRIVING WEIGHT (W)–RATE OF ROTATION (ω) CURVES FOR VARIOUS MUDS.

———— laminar flow region.
..... extrapolation to $\omega = 0$.
– – – – – – – turbulent flow region.

The Bingham yield stresses vary within a wide range, depending on the state of peptization or flocculation, from 0 to 300 dynes/cm².

The usual chemical treatment of clay-base muds primarily results in a decreasing yield stress, although in some cases the differential viscosity may decrease at the same time. A slight but definite increase of the differential viscosity, accompanied by a decreasing yield stress, was noticed after lime treatment of a red mud. This treatment, therefore, seems to have a basically different effect on the rheology of a mud from that of the conventional treatments.

An increasing clay content gives rise to an increase of both yield stress and differential viscosity, and an analogous effect is observed on the addition of barytes. Further, it is found that the more colloidal the clay, the higher the yield stress of the virgin clay suspension will be.

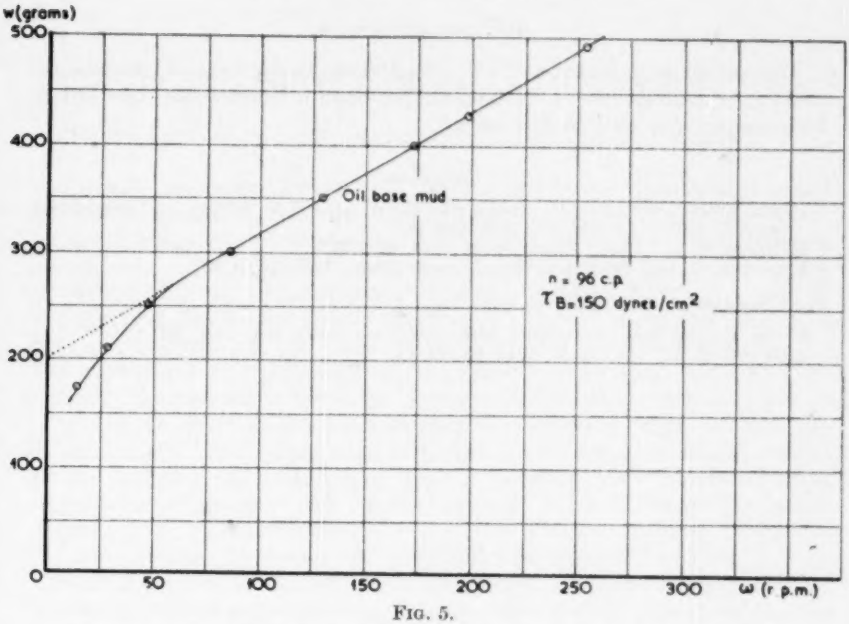

FIG. 5.

DRIVING WEIGHT (W)–RATE OF ROTATION (ω) CURVES FOR AN OIL-BASE MUD.

———— laminar flow region.
..... extrapolation to $\omega = 0$.

TABLE I.

Mud base, chemical treatment.	Differential viscosity centipoises.	Bingham yield stress, dynes/cm².	
Talang Djimar, sp. gr. 1·15	14·5	53	
,, 1·20	26·8	150	A
Tjepoe, sp. gr. 1·15	8·3	106	
,, 1·20	13·8	285	
Talang Djimar, sp. gr. 1·15	14·5	53	B
+ 10% NaCl	16·1	114	
+ 1% starch	35	63	
+ 1% starch + 20% NaCl	12·8	55	
+ 0·1% calgon	9·3	21	
+ 0·25% calgon	6	8	
+ 0·25% calgon + barytes	29·2	10 *	
+ 0·1% sil	<5	<5	
+ 0·1% NaOH	<5	23	
+ 0·1% NaOH + 0·1% quebracho	11·4	9	
Tjepoe, sp. gr. 1·20	13·8	285	C
+ 0·2% calgon	<5	60	
+ 0·2% calgon + barytes	23·7	178 *	
+ 0·3% quebracho + 0·2% NaOH	17·1	68	
Lime-treated red mud (no starch added)	40·3	23	

* Sp. gr. 1·80

ACKNOWLEDGMENTS.

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ENVIRONMENTAL CANCER AND PETROLEUM.*

By Lt.-Col. S. J. M. Auld, O.B.E., M.C. (*Past-President*).

Modern industrial civilization has brought in its train many added dangers to mankind. Not the least of these are the occupational diseases resulting from exposure to conditions arising in the course of manufacturing operations. Sometimes such adverse effects come from the absorption of definite poisons. In that case steps can be taken for the purpose of ameliorating the environmental conditions. In any event the course of the specific poisoning can often be followed and knowledge built up for the prevention and treatment of the ailment concerned. That is particularly the case where the poison is recognizable and is quick in action.

Where the effect is slow or a lengthy latent period exists, culminating in sudden and often apparently unrelated illness, recognition and control of the disease is more difficult. That is generally how it happens with environmental cancer—with cancer indeed as a whole, where the initial impetus given to the uncontrolled cell growth which constitutes the disease is often unknown because of the long latent period which follows.

That is regrettable, for, with few exceptions, the causes of cancer so far discovered are of external origin. It is, unfortunately, also true that at the present time only a fraction of 1 per cent of all cancers can be traced to known causes. To be able to trace the origin of any cancer is, consequently, of the greatest possible value in the building up of our defences in what the whole world is realizing is the greatest battle of all time which man has had to wage.

It is for such reasons that the appearance in this field of the petroleum industry is to be whole-heartedly welcomed. The oil industry is the most highly organized and most scientifically controlled of all the world's great industries. The fact that its direct participation in the causation of cancer appears to be small is of little account compared with its resources for the collection and recording of data; and in particular its ability to trace effects to identifiable materials, to conditions of production and to methods of handling or application.

In order to show how the oil world is helping to-day, and largely in Great Britain, in establishing a link between cause and effect at least in occupational or environmental cancer, it is necessary first to sketch in the background of proved or suspected causes of environmental cancer, and to proceed therefrom to the particular case of the hydrocarbons and their association with petroleum and its application.

The author's position must be made clear to prevent any misunderstanding. He is not a medical man or a biologist, and his association with this subject is that of an oil technologist. However, for many years he has helped to represent the petroleum industry, through the Institute of Petroleum, the Petroleum Board, and the Ministry of Fuel and Power,

* An address to the Northern Branch of the Institute of Petroleum, January 17, 1950.

in their various joint discussions with Government and other bodies concerned with the subject. He can, therefore, discuss the subject with some knowledge and authority, but must emphasize that his specialized interest is that of oil.

Known Causes of Cancer.

The recognized and established carcinogens are generally either physical or chemical in nature. The physical include α-, β-, γ-, and X-rays, and ultra-violet light.

The chemical list is a long one, and is continually being extended. Hueper [1] has classified them approximately as in Table I.

Table I.

Inorganic.	Organic.
Arsenic	Aromatic amines. Aniline *
Chromates	Benzole. Polycyclic hydrocarbons
Nickel carbonyl	Soot. Carbon black. Tar and pitch
Asbestos	"Paraffin oil." Shale Oil. Mineral Oils
Beryllium *	Anthracene oil. Creosote
	Azo dyes *
	Oestrogens *

* Conflicting evidence.

These are placed in Table II in their chronology of discovery, with notes added as to the investigator, the organs affected, and the nature of exposure.

Table II
(After Hueper)

Name.	Date.	Discoverer.	Organs affected.	Nature of exposure.*
Soot	1775	Pott	Skin (scrotum)	Occ. (chimney sweeps)
Arsenic	1822	Ayrton	Skin	Occ., env.
Paraffin oil	1875	Volkmann	Skin	Occ. (lignite and shale oil industry)
Shale oil	1876	Bell	Skin	Occ.
Pitch and tar	1876	Manouvriez	Skin	Occ.
Crude oils (some)	1879	Härting and Hesse	Skin	Occ.
Sun (ultra-violet)	1893	Unna	Skin	Occ. (farmers, sailors)
Aromatic amines	1895	Rehn	Bladder	Occ. (dye industry)
Röntgen rays	1902	Frieben	Skin	Occ., med.
Schistosoma hematobium	1911	Ferguson	Bladder	Env., occ. (Egypt)
Röntgen rays, radium	1911	Von Jagicz, Schwartz, and Von Stebenrock	Bone marrow (leucæmia)	Occ., med.
Anthracene oil	1913	Rambousek	Skin	Occ.
Betel nut, tobacco	1915	Davis	Mouth	Habit (India, Malay)
Diet deficiency	1919	Mouchet and Gerard	Liver	Env. (poverty diets, Africans, Chinese)
Radium	1920	Leitch and Sequira	Skin	Occ., med.
Lubricating oils	1922	Southam and Wilson	Skin	Occ. (mule spinners)
Creosote	1924	Cookson	Skin	Occ.
Benzole	1928	Delore and Bergamo	Bone marrow (leucæmia)	Occ.
Uranium	1929	Löwry	Lung	Occ.
Radioactive rays	1931	Martland	Bone	Occ., med.
Chromates	1932	Alevens	Lung	Occ.
Nickel carbonyl	1932	Stephens	Nasal sinuses, lung	Occ.
Asbestos	1934	Wood and Gloyne	Lung	Occ.
Radioactive rays	1934	Neitzel	Lung	Occ., med.
Tar fumes	1936	Kahawata	Lung	Occ.

* Occ. = occupational; env. = environmental; med. = medical.

Important and interesting as are many other of the forms of environmental causation, those tabulated which have a particular bearing on our problems are soot; paraffin, and shale oil; pitch, tar, and tar fumes; benzole, anthracene oil, and creosote; and lubricating oils.

Attention is directed to the fact that, with the exception of "lubricating oils," which in any case is a vague term chemically speaking and is largely the subject of our special interest, all of these organic materials or individual chemicals are recognizably aromatic in nature or have been formed under conditions of heat which presage their content of such substances. This applies even to the so-called "paraffin oil," shown by Volkmann in 1875 to be the cause of cancer amongst workers in the lignite and shale-oil industries. In general, it applies also to the organic chemicals on the outskirts of our province, like the azo dyestuffs and the aromatic amines.

The original observations from which our present-day lines of enquiry emanate are those of the celebrated surgeon Percivall Pott, F.R.S., of St. Bartholomew's Hospital, and recorded by him as far back as 1775.[2] His diagnosis has already been quoted at length by Prof. J. W. Cook in his important address to the Royal Institute of Chemistry on Chemistry and Cancer.[3] It refers to Pott's recognition of chimney-sweepers' cancer as a specific disease, concerning which he says:—

> "It is a disease which always makes its first attack on, and its first appearance in, the inferior part of the scrotum; where it produces a superficial, painful, ragged, ill-looking sore, with hard and rising edges. The trade call it soot-wart. . . . The fate of these people seems singularly hard; in their early infancy, they are most frequently treated with great brutality, and almost starved with cold and hunger; they are thrust up narrow, and sometimes hot chimnies, where they are bruised, burned and almost suffocated; and when they get to puberty become peculiarly liable to a most noisome, painful and fatal disease.
>
> "Of this last circumstance there is not the least doubt, though perhaps it may not have been sufficiently attended to, to make it generally known.
>
> "The disease, in these people, seems to derive its origin from a lodgement of soot in the rugæ of the scrotum."

This tremendously important observation lay practically dormant for one hundred years. Reports then began to appear regarding skin and other forms of cancer in workers connected with the coal-tar industry. These, together with reports from the shale-oil industry, and later the "mule-spinners' cancer" of the cotton industry, indicated the existence of industrial, or at any rate occupational, origin of specific forms of cancer.

Since 1915, when Japanese workers first used modern biological technique for the laboratory examination of causative agencies of cancer, there has been ever-expanding observation and recording of data connecting actual things, frequently chemical, encountered in the industries concerned with observed incidence of cancer. Thus, in the coal-tar industry it was progressively shown that raw tar, and then particular fractions boiling above 400° C, contained the carcinogenic materials which were being sought. This was quickly followed by the recognition, due to their freedom from

nitrogen and sulphur, that the most active bodies concerned were in fact hydrocarbons.

Biological Testing.

It is as well at this stage to explain the test procedure used by the biologists in determining the extent and course of cancerous activity.

The tests are made on living animals—chiefly mice, rats, rabbits, guinea-pigs, dogs, and monkeys. The most extensively employed are mice—partly because of their susceptibility, partly because of the relative rapidity with which results can be obtained.

The question must arise in the minds of oil men, or scientists in other spheres of training and activity, whether the disease so induced in animals is the same or similar to human cancer, and whether the effects are or are not generally otherwise comparable. Also, in respect of the reproducibility of the tests, their quantitative sufficiency, and the satisfaction by statistical procedure of elimination of other known or unknown conditions which might affect the conclusions to be drawn. All of these matters are of extreme importance in biological tests in a way much less known to the chemist and physicist, whose aims to produce like results from like conditions are comparatively simple in the matter of choosing the conditions.

In the past these points greatly concerned those oil technologists who were drawn into consideration of the problem of carcinogenesis : they have satisfied themselves that the procedure is standard and fully accepted ; that the standards are scientifically high—that is, they are fully organized in detail and understanding like those, for example, of the methods of the Institute of Petroleum. This important matter might be summed up to the lay technical man by saying :—

(*a*) The results are generally repeatable and reproducible. Even if there were nothing else to the procedure, this would constitute it a valuable observation and non-committal test.

(*b*) The pathological effects produced are constant and closely similar to those of spontaneous and human cancer.

(*c*) Difference of susceptibility or, as we might say, the response, of the various animals is recognized; and in the event of check-testing being needed animals up to and including the primates are available (Table III).

Tests on mice, as being the first, greatest, and best-organized screen, are therefore very important. The great laboratories use mice by the thousand. They are bred from constant, suitable, strains, and are used, or should be used, at the same approximate age and condition of health—and, of course, fed, housed, and generally looked after identically. In a modern laboratory they are, as test materials, approximating the standardization of chemical test reagents.

One aspect of this biological test technique to which attention needs constantly to be paid is the quantitative or statistical side. Even with the quick-living mouse, a series of tests requires about a year for completion. This is a big proportion of a mouse's life. It is necessary, therefore, to use enough mice for any test, and at the same time to know

TABLE III.

Reproduction of Occupational Cancers in Animals.

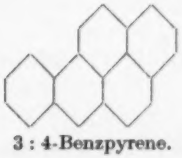
Agent.	Organ.	Species.	
		+	−
Soot	Skin	Rabbit,* mouse	
	Lung	Mouse	
Shale oil	Skin	Mouse	
	Lung	Mouse	
Pitch and tar	Skin	Mouse, goat, rabbit, dog	Monkey
Anthracene oil	Skin	Mouse	
Lubricating oils	Skin	Mouse	
Creosote	Skin	Mouse	
Benzole	Bone marrow	Mouse *	
Tar fumes	Lung	Mouse *	
β-Naphthylamine	Bladder	Dog	Rabbit, goat, mouse

* Conflicting evidence.

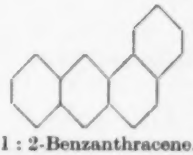
sufficiently the past history of their strain, so as to be able to allow for all the natural ills to which they are prone. Because of the long time required for the tests, extrapolation of the results must be very tempting when the quantitative factor is found insufficient. That might happen as a result of starting out with insufficient living subjects or because of some experimental disaster. But any extrapolation, or filling up of gaps for that matter, can obviously be very dangerous. It is for those reasons that biological tests must be conducted on a vast scale and with meticulous care in respect of such conditions as *can* be controlled.

THE CARCINOGENIC HYDROCARBONS.

The recognition that extracts from soot and from cancer-producing tars were themselves carcinogenic stimulated interest in the search for single chemicals capable of producing malignant tumours. In the search the pioneering work of Sir Ernest Kennaway on carcinogenic artificially produced tars was important by directing attention towards the complex aromatic hydrocarbons, and encouraging the search for the individual causes of coal-tar cancer. Eventually, in 1932, Cook and his co-workers tracked down in coal-tar pitch a strongly carcinogenic hydrocarbon, 3 : 4-benzpyrene (Fig. 1). From 2 tons of pitch they were able to separate 7 g of the material.



3 : 4-Benzpyrene.



1 : 2-Benzanthracene.

FIG. 1.

The " tracking down " of this hydrocarbon was done by a method which has more than academic interest. It may readily be brought to the

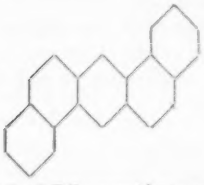
attention of oil men and questions asked about it. It is *fluorescence*. It had been observed by Mayneord and Hieger, who collaborated with Cook, that the carcinogenic tars were all strongly fluorescent and possessed fluorescence spectrum bands of similar position and distribution. Here was a possible quick clue, without having to wait for the results of biological tests—each of which involves many months or years to complete. Concentration of the extracts using this means of control eventually resulted from a variety of methods, including the chromatographic, in the separation of the 3 : 4-benzpyrene described. This has a closely related structure to 1 : 2-benzanthracene (Fig. 1) which, though itself inactive, has a similar type of fluorescence spectrum, partly in the visible. This synthetic material is the parent hydrocarbon from which nearly all the highly active carcinogenic compounds of this kind are derived.

It is clear, then, that although fluorescence accompanies the general structure of the hydrocarbons belonging to this important carcinogenic grouping there is no relationship between fluorescence and carcinogenicity. *First*, there are many known carcinogens which are not fluorescent at all. *Secondly*, although the active hydrocarbons of this kind are largely fluorescent, the reverse is not the case—as is seen from 1 : 2-benzanthracene itself. *Thirdly*, it is not fluorescence in general which is characteristic, either visible or under ultra-violet light, but the analysis of the spectrum and its classification.

These are points to be borne in mind, since as a result of Hieger's important work ill-advised generalizations have sometimes been made and suggestions offered, in respect of oils and other materials, to use fluorescence as a classification of carcinogenicity and as a guide towards the use of particular materials.

Of the many hundred derivatives of 1 : 2-benzanthracene which have been prepared, many are inactive, others only slowly active, and others again very powerful. It depends largely on the position of substitution and the nature of the substituting groups. Generally, the higher the substituting homologue the lower the carcinogenic activity. Small differences in structure may have very big effects on carcinogenicity.

The first compound of this class found to be cancer producing was 1 : 2,5 : 6-dibenzanthracene (Fig. 2).



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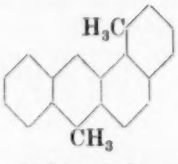
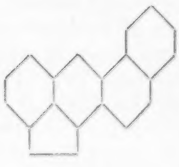


9 : 10-Dimethyl-1 : 2-benzanthracene.



Cholanthrene.

FIG. 2.

One of the most powerful is 9 : 10-dimethyl-1 : 2-benzanthracene (Fig. 2). Others may contain nitrogen, sulphur, five-ring groupings, or incompletely closed rings. Cholanthrene (Fig. 2) is of interest as being a powerfully active carcinogen related to cholesterol (Fig. 3), and the sex-hormones

œstrone and testosterone (Fig. 3), all of which are, of course, normal components of the human body.

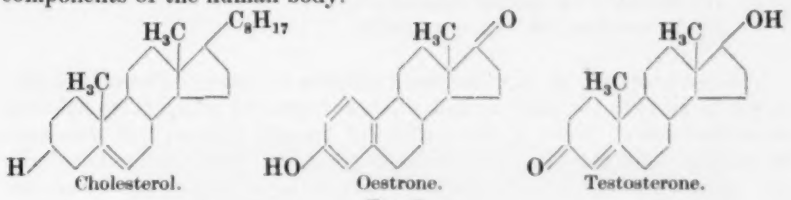


FIG. 3.

Other polycyclic hydrocarbons of the phenanthrene and chrysene series have also been synthesized and shown to be carcinogenic, but it will be realized that these are also asymmetrical ring compounds, not dissimilar in structure from the benzpyrenes and benzanthracenes.

The skin tumours produced by these synthesized or natural chemical compounds are truly malignant, and indistinguishable in nature from spontaneous and human cancers.

That is the real answer to the very natural question of what is the significance of this synthetic work? There would in itself be little point in multiplying the number of hydrocarbons and other compounds capable of inducing cancer in experimental animals. But the mere fact that the results are consistent and repeatable may have the greatest importance in the study of the form of occupational and generally environmental cancer, as well as in throwing light on the course and ultimately the cause of cancer in the human body. Whether such substances are concerned as intermediates in spontaneous human cancer, or whether there is any relationship between them and body materials of apparently allied structure is a matter for speculation. But it is obvious that here is a door which must be opened wide—and everything within subjected to the most careful scrutiny.

There are, then, two great reasons for the study of petroleum in its relationship to the cancer problem. There is the attack on what it is believed will be a relatively short-term problem—occupational cancer in the oil industry; and there is the possible application of the results of thoroughly organized research and study to the cancer problem as a whole.

It may be reiterated that such a small proportion of all human cancer can be traced to actual cause that it is of the highest importance that such clues should be followed up inexorably. In comparison with many other industries, petroleum is of small importance in cancer causation. But it must be repeated that this relatively slight connexion may be of great importance because of the highly organized industry involved, the greatly varying chemical nature of the crude oils and the processes concerned, and the widespread use of petroleum products throughout the world.

The oil industry has been concerned in the ætiology of skin cancer in the following ways :—

(a) *Occupational.*

(1) Amongst paraffin-wax workers, in shale.
(2) Amongst lubricating-oil users as mule-spinners' cancer.
(3) In the use of cutting oils.

(b) *Experimental.*

(1) As selective-solvent extracts.
(2) In cracked oils of low volatility.

It is not proposed to consider these subjects *seriatim* or chronologically. It will be more to the point to look at those regarding which there has been most discussion. Many of the matters of broader interest will then arise in passing. But first it must be pointed out that both epidemiologically and experimentally those portions of petroleum concerned are within the higher boiling ranges. So far there is no suggestion that carcinogenicity is directly concerned with the volatile low-boiling or intermediate products such as gasoline, kerosine, and gas oil. Nevertheless, that does not exclude the hydrocarbons which may be present in such fractions. Benzene itself, under certain conditions, is not free from suspicion, despite the fact that it is a chosen solvent of the biologists for the application of carcinogens to experimental living subjects.

At present potential petroleum carcinogens appear to be concerned chiefly with those fractions generally known as : (*a*) the wax distillates, and (*b*) the lubricating-oil residuums. These, in effect, cover the whole lubricating-oil range, with a boiling point from say 300° C upwards. The range would include the lowest-viscosity spindle oils up to those practically non-volatilizable at ordinary pressures, like the heavy machine oils.

It is also to be noted that the list includes on the one side shale oil and cracked fractions which have been subjected to high temperatures for their fundamentally reconstructive production, and on the other side lubricating-oil distillates and residues which by premise have not been chemically changed during fractionation, or the slight changes in which have been negated in the normal course of refining.

The distillation range in both classes would, of course, cover the possible occurrence of those carcinogenic hydrocarbons—naturally known, synthesized, or yet to come which have been referred to.

Paraffin Wax and Shale Oil.

The light oils and wax derived from shale oil have long been recognized as causes of skin cancer. Bell in Edinburgh reported scrotal cancer of a shale worker in 1876, and Volkmann is quoted by Leitch as recognizing skin cancer as a result of shale and lignite occupation in Germany one year earlier.

Dermatitis is known to occur amongst the shale-paraffin workers, but there is no record of petroleum operators with parafin wax having been subject either to dermatitis or cancerous growths.

It is most likely, even in shale, that the irritant or active constituents are not part of the wax, which is paraffinic by nature as well as by name, but rather of the oily coloured components accompanying the slack wax. These are known to be chemically reactive, and are not necessarily allied in nature to the crystalline paraffin wax. Indeed, Berunblum has extracted from Blue Shale Oil the same 3 : 4-benzpyrene as Cook identified in coal-tar pitch.

FIG. 4.

[*To face p.* 242.

Mule-spinners' Cancer.

The occupational disease of mule-spinners' cancer has attracted much attention in the U.K. It is indeed around mule-spinners' cancer that much of the interest and concern in petroleum carcinogenicity has revolved. Its history is already a trifle obscure, but it appears to be the case that Southam and Wilson in 1922 drew attention to the high incidence of scrotal cancer in Lancashire mule-spinners, and that in 1924 Leitch was able to produce tumours in mice by applying solutions of the lubricating oils involved. Mule-spinners' cancer is a skin cancer, epidemiologically associated with the occupation of cotton-spinning with the mule (Fig. 4). Operators who succumb, generally do so after a long period of working under the conditions prevailing—sometimes over twenty years. The disease may attack various parts of the body, but like soot cancer and paraffin cancer is frequently associated with the scrotum.

The conditions of operation are of importance, and have been recorded by Dr E. M. Brockbank,[4] who says :—

> " The spinner works bare-footed in vest and overall trousers without any shorts between them and the skin. As the illustration shows, he leans over the mule to join or piece with the thumb and finger the broken ends of a thread of yarn. . . . The scrotum constantly comes in contact with oil on the trousers. The vast majority of men piece with the left hand, and for this reason the left side of the scrotum is affected a similar number of times. . . ."

The temperatures in the mule-spinning rooms are excessive, and may exceed 105° F.

Brockbank also quotes Home Office records (Table IV) giving information on the incidence of the disease over some selected years.

Table IV.

	Spinners and piecers.	Cases per 1000.	Total cases.	Total deaths.
1926	48,029	1·83	88	20
1930	46,714	1·75	82	21
1936	32,232	1·27	41	12
1940	23,009	1·78	41	10
1946	17,671	2·03	36	21

He points out that the increase in number of cases per 1000 in recent years is due to the greater proportion of older spinners at work, and the greater liability of cancer of any form to occur.

Manchester Committee on Cancer.

As a result of the observations of Southam and Wilson and the work of Leitch, the Manchester Corporation some years later, in 1928, set up a large committee further to investigate cancer in general, and mule-spinners' cancer in particular. Experimental work was placed under the direction of Dr C. C. Twort and the cancer research committee under the

chairmanship of Dr E. M. Brockbank. Reports were published annually, and accounts of the researches published in the medical Press. These confirmed the observations of Leitch, and supported his conclusions that mule-spinners' cancer is caused by carcinogens present in the lubricating oil used.

This work was substantially subsidized by the oil industry—notably by the Shell Group, the Anglo-American Oil Company, and the Anglo-Persian Oil Company.

In 1934 the Manchester Committee proposed a standard for mineral oils to enable the textile industry to choose lubricants which should be

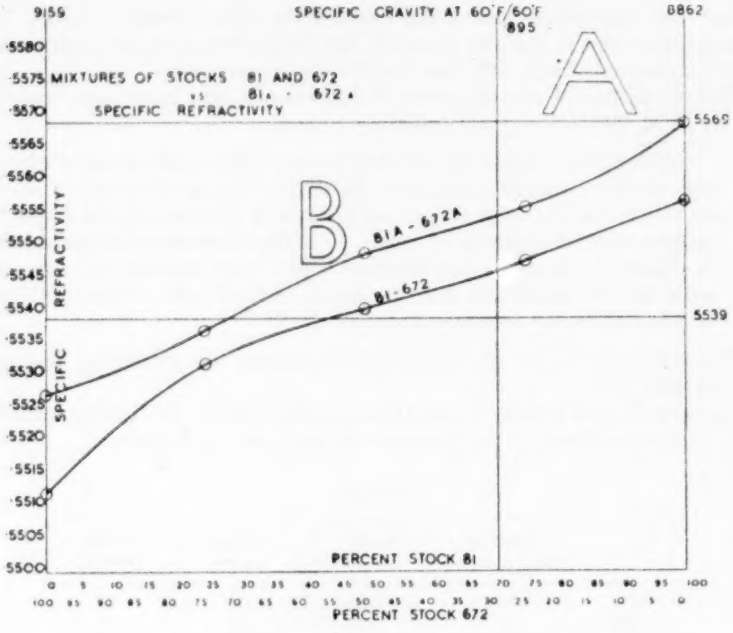


FIG. 5.

substantially free from carcinogenic properties. The criterion was believed to render tests on mice obsolescent, and consisted of a believed relationship between carcinogenicity and the refractive index and specific gravity of the lubricating oil. The specification read :—

> "Mule-spindle mineral lubricating oils should have a specific refractivity below 0·5539 when the specific gravity is above 0·895, or a specific refractivity below 0·5569 when the specific gravity is below 0·895. By specific refractivity is meant $\frac{n-1}{d}$, where n is the refractive index for d-line sodium light, and where d is density in grammes per millilitre at 20° C."

In view of the importance of the subject, the validity of the Manchester Committee's conclusions were naturally closely examined.

Data showed this specification to be unsound. For example (Fig. 5) in blends of paraffinic (Oklahoma City) and naphthenic (Gulf Coastal) oils, curves, and check-curves cross the specification limits of refractivity horizontal) and specific gravity (vertical) in such a way as to indicate that blends between 45 and 71 per cent in one case and between 29 and 71 per cent in the other are dangerous, whereas all other blends of the same stocks would be safe. Many other similarly collated data also indicated complete lack of acceptability of the specification. In addition, it was made clear that " extent of refinement "—the characteristic most likely to line up with " degree of carcinogenicity " goes in the opposite direction to the specific refractivity/density relationship when applied to paraffinic oils.[5]

By this time, however, it was over late. The too-much publicized Manchester Formula for " non-cancerous oils " had understandingly, but wrongly been widely accepted as the complete solution to the problem. This was unfortunate for several reasons :—

(*a*) The textile workers, the employers, and to an appreciable extent the medical profession were being misled as regards the facts of the case, and possibly lulled into a false sense of security. Blends of oils such as those described were by no means unlikely to exist in practice.

(*b*) The oil industry found the Manchester specification unacceptable, and many oil scientists felt that insufficient attention was being paid in the textile industry to *prevention* by cleanliness, working conditions, medical inspection, change of occupation for workers susceptible to skin trouble, and so on.

These things were known, from the petroleum industry's own experience with shale oil and occupational oil dermatitis, to be of the first importance. Indeed, paraffin dermatitis and paraffin cancer were already regarded in the shale industry as being under control and largely confined to the older men who had contracted them years previously. Also, results both in the U.K. and in the U.S.A. in the control of cutting-oil dermatitis, by systematic washing and other regularized forms of cleanliness and in the application prior to working of protective creams and ointments, were very encouraging.

Another point which seemed to support this form of approach to the problem was that enquiries in other countries—including the U.S.A., France, and India—failed to disclose the occurrence of occupational cancer in their textile trades when working under apparently similar conditions and with similar oils to those in Lancashire.

(*c*) It meant that insufficient attention was being paid to the development—or rather the testing and use, of truly non-carcinogenic oils. It had been apparent to many oil men that more drastic refinement—possibly by solvent extraction, or by treatment with such agents as might be expected to destroy the carcinogens, was the most logical approach to the problem as far as the lubricating oil was concerned.

(*d*) It delayed consideration of systematic examination of petroleum for the purpose of separating the actual carcinogens and study of their chemical structure and properties.

Wartime Conditions.

In 1943–44 arose two matters of some significance in placing the study of the carcinogenicity of petroleum on the right lines. The first was the bringing to notice by Twort of the possible carcinogenic, or otherwise noxious effect of lubricating-oil extracts, which under war conditions were in use as substitutes for extenders, plasticizers, and binding materials which could no longer be obtained.

The second was an approach to the Petroleum Board by the Federation of Master Cotton Spinners' Associations and the Amalgamated Association of Operative Cotton Spinners and Twiners, asking that oils to the Manchester Specification be made available to the textile industry. In making this request they quoted the Manchester Committee as stating ". . . testing of oils from cotton mills for carcinogenicity has been practically discontinued, as all mineral oil being generally used is pooled and is a mixture of oils. . . ." This, of course, was not at all the way in which the Lubricating Oil Pool actually operated ! But it gave the Petroleum Board the opportunity of summing up the situation, and pointing out that oils to the Manchester specification had not been asked for during the previous four years of war either by distributors or users; that such oils could undoubtedly have been supplied if wanted, and the Board was prepared at once to set aside oils meeting the specification in two ranges of viscosity—despite the fact that the efficacy of the specification was questioned. At the same time the Ministry of Fuel and Power drew attention once more to the need for the improvement of operating conditions in the cotton mills.

These two matters obviously tied up together. If, by solvent refining oil stocks from which lubricating oils are made, the extracts were more carcinogenic than the original stocks, then the refined oils must be less so. This conformed with the oil industry's past views, and the Petroleum Board arranged to finance biological testing and research on the matter at Birmingham University. Work was initiated by Prof. Haswell Wilson and Dr D. L. Woodhouse in the Cancer Research Laboratory in the Department of Pathology and under the ægis of the British Empire Cancer Campaign Committee,

After about twelve months' investigation and testing of petroleum extracts, interesting results were obtained to which separate reference will be made.

White Oils.

Throughout the extended study of the relationship of lubricating oil to mule-spinners' cancer the question of extent of oil refining has cropped up frequently. As far as the oil is concerned this has always been the chosen aspect to the problem of the chemist and oil technologist. From quite early days Twort expressed belief in white or medicinal oils being the least carcinogenic of all he tested, sharing immunity in that respect with fatty oils. The possibilities of removing reactive carcinogens from mineral oil by earth treatment, oxidation with air or chemicals, solvent

extraction, acid treatment, were all discussed, but nothing was done. That possibly was due to the limited testing facilities available, the amount and expense of the work involved, and lack of a sense of realism perhaps in those most intimately concerned.

In the early days of 1946, however, the step was taken by the Manchester Oil Refinery Group, in conjunction with Twort, of definitely recommending the use of technical or medicinal white oils as spindle oils for mule spinning. These oils are selected petroleum distillates heavily treated with sulphuric acid or oleum.

The proposal was brought to the attention of the Petroleum Board, whose advisers were quickly alive to the logic of the suggestion, and recommended that, if a *prima facie* case could be made out for the non-carcinogenicity of such white oils, they should at once be made available to the textile trade as spindle oils. Examination disclosed that the evidence available was meagre. Nevertheless, at a meeting called by the Ministry of Labour and attended by representatives of other ministries, the textile trade, and the petroleum industry, the decision of the Ministry of Fuel and Power to make white oils available as textile lubricants was confirmed, despite the scarcity and dollar cost of such oils at that time. Simultaneously, the Petroleum Board announced its further financial subsidy of research work on the subject at Birmingham to supplement the very limited information on which the decision had been made.

With the exception of a few more letters and articles in the trade journals, once again nothing happened for another extended period—nearly two years. There were practically no enquiries for the white oils and no demands for supplies—either from consumers or distributors.

In 1948, however, the Master Spinners and the Cotton Operatives again called into being the *ad hoc* Committee of 1946, with the addition of representation from the Shirley Institute. By this time there was fortunately corroboration by Woodhouse of Birmingham of the biological inactivity of white oil samples submitted by the Petroleum Board.

Decisions were thereon made by the Federation of Master Cotton Spinners' Associations to standardize on the use of white oils subject to practical tests showing them to have suitable lubricating value.

Such mill trials, carried out with plain white oils and white oils blended with fatty oil, all of comparable viscosity, showed satisfactory performance and unexpectedly very little difference amongst themselves as regards power consumption.

The *ad hoc* committee concerned has since achieved an official basis by being brought under the control of the Factory Department of the Ministry of Labour and National Service.

White Oil Specification.

It was remitted to the petroleum industry representatives to submit a specification to cover suitable white oils for adoption by the trade. This has now been done, and the draft specification is in the hands of the Committee, by whom it may be expected to be published at an early date.

The specification is based primarily on definition of nature and pro-

duction, and upon colour. It is recommended that colour should be of the highest standard known, as representing the most drastically refined oils, and consequently those likely to be the least carcinogenically active.

Later, when further testing and investigation has been carried out, it may be possible to relax the standard without danger. This joint action of the cotton and petroleum industries, with the support and understanding of the Government, is a fine example of co-operation for the common good. It makes up somewhat for the period of misunderstanding and diversity of action of the past. Expenditure of time and money, and ultimate cost of the very special oil concerned, have been no obstacle in dealing with this aspect of the fell disease.

As far as can be seen at present nothing further can be done as regards the oil.

There may, however, be unforseen snags, and it is essential there should be no false feeling of safety. It is most sincerely to be hoped that nothing will interfere with the campaign for cleanliness, for protection by means of clothing and barrier creams, and for better conditions of operation. The recommendation of the Joint Advisory Committee of the Cotton Industry (1945) for the adoption of automatic wiping-down motions and non-splash devices is good as far as it goes, but no layman can but wish that mule spinning, with its attendant conditions as described by Dr Brockbank, could be exchanged for other methods of spinning less exacting.

Fatty Oils.

Statements to the effect appear from time to time in the technical and trade Press that animal and vegetable fatty oils are non-cancerous. Twort has recorded all such oils tested by him as being innocuous; but he has also pointed out that oleic and linoleic acids (which may, of course, be present to an appreciable extent in commercial fatty oils and to a small extent even in well-refined oils) are capable of producing non-malignant tumours in mice. They are also capable of amplifying the cancer-producing effects of certain chemical compounds.

It has also been stated that when using sesame oil as a carrier for chemical carcinogens the blanks with sesame alone were not free from activity.[3]

These matters are mentioned, as the specification for white oils referred to may factually or tacitly permit compounding. In this it would be in line with the observations of the Manchester Committee. It is well to realize, however, that there is no full clearance for fatty oils, and in view of the difficulty of defining their nature and their purity the author would suggest limitation of their use until further work has been done.

All concerned would wish to express their appreciation to Dr C. C. Twort for his devotion to his purpose of eliminating mule-spinners' cancer. The single-mindedness of Twort and his co-workers—and of the Manchester Committee as a whole—has been responsible, both directly and indirectly, for much of the progress made.

Carcinogenicity of Oil Extracts.

The work of Woodhouse at Birmingham on behalf of the Petroleum Board, to evaluate the carcinogenicity of oil extracts, covered materials

from stocks derived from different crudes by various processes of solvent treatment. Such treatment is a process of physical extraction with selective solvents. These remove the more aromatic and naphthenic-ring-type compounds, which include many of the more chemically susceptible constituents, so that the raffinate is much more resistant, to oxidation for example, and is more paraffinic in nature than the original oil.

The materials tested at Birmingham were all products from feed-stocks derived variously from :—

Venezuela (Colon, Lagunillas, Concepcion, and Tia Juana),
U.S.A. Gulf Coast (West Beaumont),
Colombia,
Equador,
Middle East (Persia),
U.K. (Eakring).

The solvent-extraction processes concerned included Duosol (propane/Selecto), Edeleanu (benzol/SO_2), and furfural.

Altogether, twelve petroleum extracts of different kinds were tested over a period of some twelve months. A second series of confirmatory tests followed, and gave almost identical results. The first series were compared by check-tests with known carcinogens and with certain chemicals normally used as plasticizers and extenders in the rubber industry.

The results varied quantitatively from one material to another, but showed that solvent refining tended, where they existed, to concentrate carcinogens in the extracts. The most active were lower in biological activity than corresponding coal-tar products and less noxious than certain materials already in use. Nevertheless, it was apparent that such products should be used with circumspection and under controlled conditions, especially avoiding continual bodily contact.

Recently some attention has been directed towards the use of petroleum extracts as core oils in foundries, taking the place of linseed and other products less readily obtainable. There can be little connexion between such recent use of extracts and a believed above-normal incidence of cancer amongst foundry workers; but it draws fresh attention to the possibility of all decomposition products of organic matter at high temperature being carcinogenic.

Cutting Oils.

In a recent paper by Dr Cruickshank and Prof. Squire [6] attention is drawn to the possible effects of exposure to mineral oils of workers in engineering processes; and particularly to the use of cutting oils in automatic machining. Under these conditions workers are susceptible to oil folliculitis (inflamation of the hair follicles), and the great majority become affected. Moreover, about one-third of those examined contracted warts of one of two kinds. These warts are of a type known amongst tar-

workers and mule-spinners. There were in addition some cases of precancerous skin condition and one of scrotal cancer.

These observations may have to be regarded as warning signs, and certainly call for study and amelioration where possible of the conditions of operation. It seems to be the case that whilst a little of the cutting oil may be oxidized at the tool edge, the considerable loss of oil known to occur in use is due to the formation of very fine spray which deposits on the surroundings, including the operators, as a thin film. The initial inflammation is mostly on the hands and forearms, but clothing becomes charged with oil, and the general conditions in this respect are not dissimilar from those met in mule-spinning.

The conclusion to be drawn is that if improperly dealt with continuous exposure to cutting oils is a hazard. This is supported by certain epidemiological data and also by biological tests. Magnification of the effect is undoubtedly caused by irritation from clothing, injury, and abrasion from metal particles, and in this respect falls within the class of action of oil and other occupational dermatitis, to the avoidance of which much attention is nowadays paid in factories.

In this connexion Cruickshank and Squire urge stricter methods of prophylaxis—reduction of actual skin contamination by oil, improved anti-splash devices, and use of more suitable clothing; higher standards of cleanliness; organized use of effective barrier creams; regular medical inspection; and attention to personal susceptibility.

To those interested in the nature and use of barrier creams a previous paper by Cruickshank [7] on the subject of their evaluation may be recommended. As protectives, the soapy type of oil-resistant barriers seem to be of limited effect, and have the disadvantage that when after a limited time they are penetrated by the mineral oil they give no aid to subsequent removal. Greasy protectives, on the other hand, rapidly mix with the contaminating oil, but do assist subsequent cleansing.

In view of the dubious nature of some of the protective components, it is clear that a great deal more work is required on the subject.

Cracked-oil Products.

Modern refinery practice is largely concerned with the reconstitution of petroleum hydrocarbons by means of heat and catalysts. Under the conditions of cracking and reforming, most of the new products are molecularly relatively simple. But there is always a small proportion of heavier materials formed by re-condensation and polymerization. These, when distillates, may range in boiling point up to the gas oils and light fuels. They are preponderantly aromatic in character, and having been subjected to heat treatment are not readily susceptible to heat. Their molecular-weight range, for example M.W. 230–250, would include that of many of the hydrocarbon carcinogens previously mentioned. In view of their nature and mode of origin it is not surprising that biological testing has shown some of these fractions to possess carcinogenic activity. This has resulted in the suggestion being examined by the medical section of the American Petroleum Institute, to which reference will be made later.

Organization of Research.

Institute of Petroleum Research Group No. 2.

The work sponsored at Birmingham University by the Petroleum Board started by biological testing of white oils and petroleum extracts. An account of this work is contained in a paper by Woodhouse and Irwin.[8]

It had been determined by the Petroleum Board's advisers, however, that work on the carcinogenicity of petroleum should be put on a fundamental basis as soon as possible. For this purpose the Board promised the necessary funds, and arrangements were made with Birmingham University to undertake the biological side of the research work involved. These arrangements were well under way when the Petroleum Board was dissolved. Amongst its last activities the Board, with the concurrence of the Ministry of Fuel and Power, approached the Institute of Petroleum to accept responsibility for continuation of the work, and offered a substantial sum to initiate the research. It was implicit that further financial support, when needed, would be forthcoming from the individual oil companies.

The Institute accepted the responsibility, and implemented it by the formation (under its Research Committee) of Research Group No. 2, over which the author has the honour to preside.

The Group consider that work embarked on should not be of an applied or *ad hoc* nature, but an endeavour to separate and identify the active components present in petroleum and determine their properties. As there are hundreds of different oilfields and many hundred different crude petroleums, it is necessary to be realistic and make a limited choice. This choice is governed by :—

(*a*) Difference of type and distribution.
(*b*) Importance in extent of production.
(*c*) Content of lubricating-oil fractions, since carcinogens, where already indicated, had occurred in the heavier distillates.
(*d*) Supplies being the complete and untreated crudes.
(*e*) Authenticity and repeatability of experimental supplies.

Medical Research Council.

Quite separately, as a result of the attention paid to mineral-oil carcinogenicity, the Medical Research Council at the end of 1948 set up a Committee with the terms of reference :—

> " to initiate and carry out research into the carcinogenic action of mineral oils and compounds of other origin with which they may be combined in use."

The Medical Research Council, it should be explained, is a body of the Privy Council, and as such possesses all the powers necessary to embark upon such action.

The Committee thus formed is of high calibre, and includes specialists in cancer pathology, the chemistry of cancer, biological testing, statistics, and petroleum technology. The various ministries concerned have also nominated representatives to attend as may be required.

The M.R.C. Committee works closely with I.P. Research Group No. 2,

who in effect act as their oil executive. The programme embarked upon is broadly the following :—

(*a*) Attention is directed in the first instance to skin cancer, whilst retaining interest in other forms.

(*b*) Biological research is directed by Prof. Squires at Birmingham, other associations being retained.

(*c*) Chemical research is directed by Prof. Cook at Glasgow, in direct association with I.P. Research Group, No. 2.

(*d*) Research Group's initial choice of three crude oils is confirmed, together with arrangements for their fractionation. The oils are,

(1) *Kuwait* (*Kuwait Oil Co.*). Extensively produced Middle East crude, likely to be much used in the U.K.; of paraffinic–asphaltic base and containing lubricating-oil fractions.

(2) *Lagunillas, Venezuela* (*Shell Petroleum Co.*). Typical naphthenic crude of known history and producing well-known lubricating distillates.

(3) *Oklahoma City, Mid-Continent* (*Socony-Vacuum Oil Co.*). Typical source of Mid-Continent distillate, bright stock, and residual lubricating oils.

Substantial supplies of the oils have been received, and initial fractionation has been completed at the Thornton Research Centre by distillation at delimited temperature using vacuum and steam. All fractions are being tested biologically as produced, and the course of subsequent fractionation decided thereon.

Ultimate separation of close fractions will be by methods least likely to cause chemical change of any active component present. The exact procedure will be decided by the chemical and petroleum interests. It is hoped to discover additional methods to those known for following the course of concentration of the carcinogenic components and effecting their separation.

Close contact has been established with the American Petroleum Institute Medical Committee, and arrangements made for the exchange of information and results. As the A.P.I. is embarking on a substantial research scheme it is hoped exchange visits of workers will be arranged.

It may be agreed that what is being done is commensurate with the broad outlook of the oil industry and of medical research. It is sincerely hoped that from it will emerge results leading to the elimination of environmental cancer as far as petroleum may be concerned. Also, that knowledge will accrue which will show fresh paths leading to the understanding and control of cancer as a whole.

This address would be wrong if it left an exaggerated estimate of the carcinogenicity of petroleum. That effect is small even in the small proportion of known causes of cancer. Attention should be paid more to cleanliness and the avoidance of continuous contact with oil, than to the nature of the oil. We must learn to " touch pitch without being defiled," as has already been done with many poisons in industry.

And on the long-term research it might even be that the persistent claims coming from Russia [9] of successful treatment of malignant tumours

with ultrasonic oil emulsions are an indication of the existence of ameliorative properties in some forms of petroleum, or even in the petroleum carcinogens themselves.

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Oilfield Exploration and Exploitation.

Geology.

641. A cross-section board. B. O. Prescott. *World Oil*, Jan. 1950, **130** (1), 69.—A method is described whereby geological cross-sections are built up on a vertical baseboard, coloured white. Well logs are pinned on the board, and correlations are shown by dark-coloured nylon threads. The completed section is photographed on orthochromatic film, and photo copies of the section can be distributed.

The method is cheap and fast, and the sections compare favourably with those prepared by other methods. C. A. F.

642. Aerial photography in geological survey. M. Konecki. *Nafta*, Oct.–Nov. 1948, **4**, 324–5.—Describes how useful photography may be to save unnecessary labours. To cover its expenses it may be combined with military flying. Stereo-photography may help to identify features of the ground. Heavily undulated ground requires scale 1 : 20,000 and plateaus 1 : 8000. M. S.

643. Submarine geology and stratigraphy. F. P. Shepard. *World Oil*, Dec. 1949, **129** (9), 72.—Recent investigations of the geology of the continental shelves has indicated that few areas show a simple gradation from coarse to fine sediments in an offshore direction. Average grain size varies irregularly over the shelf, and the coarser sediments may occur on submerged hills and the finer in the hollows. Coarse sediments in deep water may be lag-gravels deposited by oceanic currents, or they may be inherited sediments not covered by recent deposits.

Evidence from offshore wells suggests that the continental shelf is not a wave-built terrace, but a submerged shoreline. Submarine canyons, and coarse sediments in deep water are evidence of considerable submergence during the late Tertiary.

C. A. F.

644. Obtaining and interpreting continuous logs in wells in order to make completions. W. Ziloff. *Rev. Inst. franç. Pétrole*, Oct. 1949, **4** (10), 566–75.—Equipment is described which has been devised for semi-continuous collection of cuttings from the drilling mud. These cuttings are separated into different sizes and collected for known depth intervals. For a variety of reasons cuttings are mixed and cannot be allocated with certainty from the time of collection to their actual source.

The hydrocarbons in cuttings can be released by agitation in water under vacuum, and the nature of the gases is determined by noting the ignition temperatures. The cuttings are then submitted to ultra-violet-light examination. Subsequently, they are treated with solvent, and the residues obtained from the solution are examined for fluorescence. An increase in hydrocarbon content indicates proximity to an oil horizon. Horizons with favourable indications can be cored or drillstem tested. The various tests are intended to prevent oil horizons going unnoticed, and to avoid useless coring.

Drilling speeds (rates of advance), which depend on many factors, can be used as a guide to rock hardness; in particular, they may serve as a guide to porous zones within limestones. The nature of the cuttings should be used as a check. Drilling speeds may therefore aid in getting better completions. The speeds may be determined manually (by noting time for known descent of drillpipe) or automatically by the Geolograph, the Martin–Decker apparatus, or an electrical device associated with the crown block.

G. D. H.

645. International developments. Anon. *Oil Gas J.*, 25.8.49, **48** (16), 89–90.—It is reported that the Russian oil output in 1946 was 12% above 1945, and the succeeding yearly increases were, respectively, 21, 18, and 12%.

The Raman Dag field in Turkey is now giving about 2100 b.d.

1 Suderbruch, 6 km northeast of Steimbke in Germany, has obtained oil in the Cornbrash at about 6800 ft. 34·5° A.P.I. oil was produced at 190–250 b.d. The structure seems to be a low fold between the Lichtenhorst and Eilte salt domes.

G. D. H.

646. Oil and gas exploration in the Four Corners area of Arizona, Colorado, New Mexico, and Utah. J. L. Tatum. *World Oil*, Nov. 1949, **129** (8), 69.—The area is divided into the following structural provinces: the San Juan basin, Black Mesa basin, Paradox Salt basin, and the Colorado Platform. The San Juan and Black Mesa basins are large and saucer-like with flat-lying beds. Superimposed structures have low relief. The Paradox Salt basin is believed to be a deep, tilted graben, and it contains steep-sided anticlines with crestal extrusions of Pennsylvanian salt. The Colorado Platform is relatively flat with regional uplifts occupying the area between the basins.

The formations range from Devonian to Eocene, and Ordovician may be present in the basins at depth. Oil is produced from Pennsylvanian limestones, Permian sandstones, and the Upper Cretaceous Dakota sandstone. There are shows in the Trias and Jurassic.

Recent discoveries include Dakota oil and gas at Kutz Canyon, Pennsylvanian oil and gas at Boundary Buttes, and Permian gas at Green River.

Likely areas for future development are small structures along the rims of the regional uplifts, possible marine Permian and Pennsylvanian wedge-outs against the salt anticlines, and Mississippian and Devonian accumulations in the deep basins. Reef limestones may be developed along the eastern and southern rims of the Paradox basin.

C. A. F.

647. Oak Creek discovery. G. M. Wilson. *World Oil*, Jan. 1950, **130** (1), 65.—Prentiss I, near Oak Creek in northwest Colorado, produced 250–300 b.d. of 37·9° oil from a 29-ft Lower Morrison sand from 6670 to 6699 ft. The well is situated on the Yampa anticline, a broad northwest–southeast-trending feature on the eastern edge of a large sedimentary basin. An east–west fault crosses the southern part of the structure, and

there is a westward dipping thrust on the east side. There is little or no closure at the surface, but it may be developed at depth. The discovery indicates possibilities of additional fields in a large surrounding area. C. A. F.

648. Leasing activity reaches high level in Dakota. A. G. Sorlie. *World Petrol.*, Oct. 1949, **20** (11), 51.—About 9 million acres, mainly in central and western North Dakota, are now under lease. About a score of major oil companies and many minor companies are represented in the state. Most leases run for ten years, with one-eighth royalty, 10 cents/acre annual rent, and 10 cents/acre bonus.

Most formations from Cambrian to Mississippian are present, but thereafter deposition was more restricted. Later there was Mesozoic deposition. Reservoir rocks are considered to exist. A number of wells were drilled a considerable time ago, and two reported oil showings at about 6800 ft. Stratigraphic tests are now being drilled. G. D. H.

649. 7,500,000 acres under lease after big blitz campaign in North Dakota. C. J. Deegan. *Oil Gas J.*, 18.8.49, **48** (15), 80.—Since March 1949 about 7,500,000 acres have been leased in North Dakota, many leading companies being involved. A stratigraphic test is under way in Burleigh County, and six seismic and two gravity-meter crews are at work. Devonian reef strikes in Alberta gave the main impetus to this campaign, and the Williston basin may be considered as an extension of the Alberta syncline.

There was an earlier play between 1940 and 1943 in which 4,500,000 acres was leased because of the discovery of surface structures near the deep part of the Williston basin. Seismic work indicated that the north–south Nesson anticline was steeper at depth. Other Tertiary structures, some exceeding 100 ft in closure were noted. These generally run northwest–southeast. The regional westerly dip of the basement is about 25 ft/mile. In the deeper part there may be 7000 ft of sediments between the Cretaceous and the pre-Cambrian. Wedging must occur below the Cretaceous. G. D. H.

650. Oil and gas developments in Florida, Georgia, and Alabama during 1948. H. Gunter. *Oil Gas J.*, 19.6.49, **48** (2), 337.—In about 1900 the first well for oil or gas in Florida was drilled at Pensacola, Escambia County. Three shallow wells were drilled prior to 1902. Then attention was given to the Ocala uplift area, and there was spasmodic work involving at least eighty-seven wells until 1939, when the first 10,000-ft well in Florida was drilled. In 1943 the Sunniland field was opened with production at 11,613–11,626 ft in a Lower Cretaceous (Glen Rose) limestone. Since 1940 129 wells have been drilled. One, 30 miles east of Key West, Monroe County, was stopped at 15,455 ft in dense Lower Cretaceous limestone with anhydrite and irregular shows of dead oil.

During 1948 Florida produced 291,221 brl of oil from eight wells; the cumulative output was 650,830 brl. Early in 1949 a further producer was completed 4 miles northwest of Sunniland.

The first well drilled for oil in Georgia was near Louisville, Jefferson County, in 1905. It was stopped at 1143 ft in basement. From 1918 to 1938 there was little activity, but in the next ten years thirty-six wells were drilled in nineteen different counties in the coastal plain of southern Georgia. The deepest wells were about 7500 ft. Some wells entered basement, others stopped in Eocene, Cretaceous, Triassic, and Palæozoic rocks. The Palæozoic rocks are unaltered.

The first wells for oil in Alabama were drilled in 1865 in Lawrence County in the north. Some got oil, and others had shows. At least 501 wells had been drilled to April 1949. The first commercial production was obtained at Gilbertown in 1944, from the Selma at 2575–2585 ft. The field now has thirty-four wells, and produces, from the Selma and Eutaw, about 1245 b.d.

A big salt dome has been found 40 miles north of Mobile in Washington County. It is 2 miles across and 400 ft below the surface. G. D. H.

651. Lithologic criteria of Mississippian rocks in western Kansas. J. R. Clair. *World Oil*, Nov. 1949, **129** (8), 61.—The Mississippian of western Kansas, previously subdivided on insoluble residue criteria, can now be subdivided lithologically, as a result

of detailed sample work. The lithology of the component Chester, Meramec, Osage, and Kinderhook is described in detail.

The Chester consists of an upper grey, oolitic, slightly porous limestone; a middle fine to coarsely crystalline limestone, with interbedded shale and lenticular sand; and a lower shale series with interbedded thin sands and limestones.

The Meramec is subdivided into the Ste. Genevieve, St. Louis, Spergen, and Warsaw formations. The Ste. Genevieve is a sandy, oolitic, dense limestone with a chert base. The underlying St. Louis consists of an upper oolitic limestone and a lower dolomite with chert. The Spergen is a grey to buff crystalline limestone with dolomite. The Warsaw is a mottled, crystalline limestone with dolomite and glauconite.

A regional unconformity separates the Meramec and the underlying Osage. These are subdivided into the Upper Burlington—Keokuk chert and the Lower Fern Glenn cherts, dolomites, and limestones.

The Kinderhook, at the base of the Mississippian, is a coarsely crystalline, oolitic, cherty limestone. C. A. F.

652. Louisiana's La Salle Arch yields another field. C. J. Deegan. *Oil Gas J.*, 11.8.49, **48** (14), 125.—The La Salle Arch is a regional high in east central Louisiana near the west side of the East Louisiana Salt Basin. The Arch runs northwest–southeast and has provided much Wilcox oil—Tullos Urania, Olla, Georgetown, Little Creek, Trout Creek, Nebo-Hemphill, Catahoula Lake, Saline Lake, etc. The North Catahoula Lake field has just been opened by two Cretaceous (Wilcox) wells, one flowing and the other pumping. G. D. H.

653. Offshore drilling record; three discoveries in one week. L. S. McCaslin. *Oil Gas J.*, 1.9.49, **48** (17), 24.—The Phillips–Kerr–McGee well, 3 miles offshore, in the West Cameron area, flowed 934 b.d. of 42·3° of oil from 10,390–10,408 ft, on a $\frac{7}{64}$-in choke. The oil is in the Miocene. Two possible shallower producing zones have not been tested.

Stanolind's A-2 well, 10 miles of Cameron Parish, tested 462 b.d. on a $\frac{1}{4}$-in choke, from the Lower Miocene at 8823–8828 ft. The oil is 35°, and the gas/oil ratio 570.

Barnsdall *et al.* well in the Breton Sound area, off Plaquemines Parish, flowed 230 b.d. on a $\frac{5}{32}$-in choke, from 5809–5812 ft. The oil is 25·1°.

A table lists the post-war discoveries off the Louisiana coast. G. D. H.

654. Prospects bright for several more 1949 discoveries in Mississippi. J. K. Wright, *Oil Gas J.*, 19.5.49, **48** (2), 294.—Mississippi's first field was the Amory gas field opened in 1926. This produced less than 2000 million cu. ft. The Jackson gas field, opened in 1930, had 200 wells. An oil and gas board was then formed, and since then the law has been changed. The policy is to encourage oil and gas production while avoiding waste. Taxes were fixed recently.

The first well for oil or gas was drilled to 1842 ft in 1903, and the first 400-ft well was drilled in 1921. In 1929 a well north of Meridian had several oil shows in the Tuscaloosa. A closed-fault structure near Quitman gave heavy oil on test, but no commercial production. The Midway salt dome was discovered by a well. Geophysical work revealed the possibility of an extensive salt basin in central Mississippi. The Tinsley oilfield was discovered in 1939. Next came Pickens and the Cary oilfield, which was never prominent. Eleven salt domes had been discovered by 1943. In 1943 the Brookhaven field was opened with production in the lower Tuscaloosa. Then followed Eucutta, Flora, Cranfield, Heidelberg, Gwinville, Mallalieu, Baxterville, Bruinsburg, Langsdale, Carthage Point, SoSo, Hub, Fayette, Quitman, LaGrange, Kings, and Pine Ridge. 1947 was the most active year from the point of view of drilling, and the McBride, Sandersville, Oldenberg, and Yellow Creek fields were opened; Lower Cretaceous production was opened at Ovett. Five more salt domes were discovered.

In 1948 oil and distillate production exceeded 45,500,000 brl, and the La Grange-South, Roxie, Sandy Hook, and East Yellow Creek fields were opened. G. D. H.

655. Another pre-Permian strike for S.E. New Mexico. C. J. Deegan. *Oil Gas J.*, 28.7.49, **48** (12), 357.—1-BTB State, a well in northwest Lea County, New Mexico in drillstem tests flowed gas and distillate from the Pennsylvanian at 8541–8580 ft. and oil at 8788–8862 ft. A drillstem test of the Devonian at 10,090–10,150 ft flowed

gas and 59° oil. A test at 10,199–10,250 ft recovered salt water. The formation tops were: Pennsylvanian 8522 ft, Mississippian 9865 ft, Devonian 10,120 ft.

The 1-BTA discovery, 4 miles to the north, was completed in the Devonian at 10,950–10,965 ft, and on test with a ½-in choke gave 73 brl/hr of 44·4° oil. This well entered Ellenburger at 11,670 ft and basement at 11,709 ft. The indicated water levels in the two wells differ. G. D. H.

656. A new Pennsylvanian hit for Lea County N.M. Anon. *Oil Gas J.*, 12.5.49, **48** (1), 139.—1 Betenbaugh, 3 miles north and 4½ miles west of the discovery well of the Crossroads field, has flowed 46·9° oil at 35 brl/hr in a drillstem test of the Pennsylvanian at 9591–9641 ft. The gas/oil ratio was 1818 cu. ft/brl, the flowing pressure 1250–1500 p.s.i., and the closed-in pressure 3550 p.s.i. after 15 min. The pay is probably a reef-type limestone. The well is probably on the south flank of the Red River Uplift. G. D. H.

657. Dakota and Muddy strikes step up Denver Basin play. J. A. Kornfeld. *World Petrol.*, Nov. 1949, **20** (12), 54–67.—Gurley, in Cheyenne County, is the first Nebraska oil find west of the Nemaha granite ridge. It produced from the Cretaceous. East of the ridge four fields produce from the Hunton. Gurley is on the northeast flank of the Denver basin, and has two 4400-ft producers. Borie in Laramie County, northeast Wyoming, produces from the Muddy as does Horse Creek, 22 miles to the north. Gurley production is from the Dakota. Two semi-wildcat dry holes have set limits to the producing area.

On the west side of the Denver basin the Ingleside tongue of the Pennsylvanian Casper formation is a potential reservoir. A fractured dolomite in the base of this formation carried oil, but gave no oil in drillstem tests.

Horse Creek is on a gravity and seismic anomaly. The discovery gave 580 b.d. from the Lakota at 5451 ft. Production in from an area 3 miles long and two to five locations wide on a 40-acre spacing. The main output is from the Muddy sand. At Greasewood, in eastern Wild County, the discovery well has given 250,000 brl. The total area may be 300 acres. There is a gentle, faulted anticline which plunged N. 70° W.

There are a series of maps and sections, and tables give Cretaceous production statistics, drilling results, the distribution of geophysical activity, and some well logs. G. D. H.

658. Pre-Pennsylvanian Geology of the Anadarko basin's Hugoton embayment. J. C. Maher and J. B. Collins. *World Oil*, Dec. 1949, **129** (9), 61.—The Hugoton embayment, or the Dodge City basin, is a synclinal area bounded by the Sierra Grande Uplift, the Las Animas Arch, and the Central Kansas Uplift. Pre-Cambrian, Cambrian, Ordovician, Mississippian, Pennsylvanian, and Permian formations are present in the basin.

The Cambrian and Ordovician consist of the Lamotte Sandstone, Arbuckle, Simpson, and Viola. The Lamotte is a white sandstone of varying thickness. The overlying Arbuckle is a sandy dolomite at the base and a finely crystalline dolomite at the top. It is variable in thickness due to post-Arbuckle truncation. The Simpson, which is a dolomitic sandstone with interbedded shale, is present only in the southeastern part of the basin. It is overlapped by the Viola, a dolomitic limestone series, which is present throughout the area, excepting along the eastern flank of the Sierra Grande Uplift, where the Simpson and Viola have been bevelled by post-Ordovician erosion.

The Mississippian consists of the Kinderhook, Osage, Meramec, and Chester; unconformities are present between each group. The Kinderhook is a limestone with chert, and locally a sand is developed at the base. The overlying Osage has a shallow, glauconitic limestone facies, and a deep, shale and limestone facies. The group laps out to the west against the Sierra Grande Uplift. The Meramec includes the Warsaw, Spergen, St. Louis, and Ste. Genevieve limestones, and varies in thickness due to thinning both at the top and bottom, by erosion of the upper limestone and by onlap of the group to the west, north, and east. The Chester consists of limestones and interbedded shales and sandstones, and it wedges out to the south beneath the Pennsylvanian.

Oil and gas are produced from Permian limestones and dolomites, Pennsylvanian sandstones and limestones, and the Mississippian Upper Chester limestones.

Chief objective has been the Pennsylvanian, but wedge-outs of Mississippian limestones against the Pennsylvanian unconformity and local facies change within the Meramec may provide traps for accumulations in older rocks. The Cambro–Ordovician has shown few oil indications.

Twelve maps illustrate the stratigraphy of the area. C. A. F.

659. Permian basin continues to hold attention. Anon. *Oil Gas J.*, 19.5.49, **48** (2), 383.—18-B Cowden on the Central Basin platform, east of the Dollarhide field in Andrews County, Texas, is 600–700 ft structurally higher than the dry hole which bounds Dollarhide on the southeast, although 2000 ft deeper than Dollarhide. It shows signs of being a producer on the Devonian and Fusselman. G. D. H.

660. Estimation of oil, gas reserves in Gulf Coast. P. Weaver. *Oil Gas J.*, 19.5.49, **48** (2), 346.—Early reserve estimates included only areas actually producing. Estimates before 1935 made no attempt to assess the amount of gas with the oil. More recent estimates take note of production history and pressure behaviour. In January 1949 the Texas reserves were placed at 12,484,218,000 brl of oil, 2,074,674,000 brl of natural-gas liquids, and 95,708,553 million cu. ft. of gas. In 1948 Texas produced 993,030,000 brl of oil and natural-gas liquids, while 1,820,322,000 brl of these was discovered. Gas production was 2,710,422 million cu. ft. of gas in 1948; additions to reserves were 8,393,357 million cu. ft. G. D. H.

661. 126 wells drilled below 12,000 ft in 1948 in Texas–Louisiana coastal area. E. M. Abbott. *Oil Gas J.*, 19.5.49, **48** (2), 203.—Louisiana has 303 wells below 12,000 ft, and Texas seventy-three in the Gulf Coast area. The deepest is on the Millican dome in Brazos County, Texas, and was abandoned at 16,655 ft in 1944. The deepest production is at 14,243 ft at Weeks Island, Iberia Parish, Louisiana. Fifteen fields in Louisiana, two in Texas, and one in Mississippi produce below 12,000 ft. It is considered that in the Gulf Coast area the economic limit for deep drilling is being rapidly approached. Producible oil may occur down to 20,000 ft, although sands may be greatly reduced in porosity and permeability.

Tables give the wells drilled below 12,000 ft by years, and the totals by states, a list of the numbers of producing wells in the fields, and a list of the wells deeper than 13,000 ft. G. D. H.

662. Reef trend search on west flank of Bend Arch. C. J. Deegan. *Oil Gas J.*, 21.7.49, **48** (11), 121.—The possibility of a Pennsylvanian reef trend connecting Round Top field with the Jameson field has been considered. 1 E.A. Ater in northwest Nolan County has, however, found no Canyon reef, for like the Strawn the section was almost wholly shale. The Cisco had a few limestone stringers. This well is on the west flank of the Bend Arch. It topped the Ellenberger at 7086 ft, and several drillstem tests recovered oil. Cores at 7097–7105 ft were fractured dolomite and chert with oil staining. G. D. H.

663. Gulf Coast oil. C. J. Deegan. *Oil Gas J.*, 19.5.49, **48** (2), 190.—Texas and Louisiana have about 900 fields in the Gulf Coast area. Since 1901 and up to the beginning of 1949 the area had given 5400 million brl of oil; its reserves were about 6700 million brl.

The oldest rocks outcrop farthest inland, and the formations thicken towards the coast. The most favourable zone for oil accumulation is generally at a point intermediate between the outcrop and the thickest zone of each formation. Thus the producing horizons become progressively younger as the coast is approached. Offshore producing zones are probable, but will be costly to develop.

Twenty-four fields gave 40% of the 1948 production, and they have given 67% of the cumulative output. They have about 35% of the proven reserves.

Fundamental research is being pursued in an endeavour to discover the reasons for the siting of the producing zones, and in particular the major fields are being studied. G. D. H.

664. Benedum field is established as three-pay major reserve. C. J. Deegan. *Oil Gas J.*, 19.5.49, **48** (2), 183.—The Ellenburger pay, which is 11,000–12,000 ft deep, covers at least 4400 acres at Benedum. The average pay thickness may be 250 ft. It is

conservatively estimated that recoveries may attain 20,000–25,000 brl/acre, by comparison with Big Lake. The Fusselman (Silurian) pay is expected to give 12,000–15,000 brl/acre. The average thickness is 75 ft, and the porosity is granular. The productive area may be 5000–5500 acres. Pennsylvanian production may be obtained over an even greater area. The single Pennsylvanian producer, west of the fault, gives oil from the Strawn and Bend at about 10,000 ft; two other wells are east of a 600–800-ft fault, and produce from the Bend. The eastern sector may be broken by several faults.

The structure is an asymmetrical dome. Three stratum contour maps are included. G. D. H.

665. Tertiary in Rocky Mt area drawing interest. C. J. Deegan. *Oil Gas J.*, 14.7.49, **49** (10), 133.—1 Ute Tribal has tested 31° paraffin-base crude at 68 brl/hr from 9351–9392 ft. This well is in Uintah County, Utah. 1 Badwater unit in Natrona County, Wyoming, has had shallow Tertiary shows at about 1914 and 2236 ft, and scattered shows and staining between 2236 and 2980 ft. This well is in the Wind river basin. G. D. H.

666. Utah's deepest producer. J. W. Gibson. *Oil Gas J.*, 14.7.49, **48** (10), 82.—A well on the Upper Valley anticline in Garfield County, Utah, is the state's deepest producer. The anticline trends N.N.W.–S.S.E. with dips of 35° to the west and 7° to the east. The well is in the Kaiporowits basin.

A depth of 8857 ft was reached in 516 days. The Tropic, Dakota, Morrison, Summerville, and Entrada were met down to 1509 ft. The Kaibab limestone (equivalent to Embar and Park City) had oil-stained sand and dolomite from 6042 to 6302 ft, and was cored and tested. The lower part has good permeability, but was water-flushed. There was a further show at 6430–6438 ft, and oil-cut mud was recovered in drillstem tests of dense fractured dolomite at 6714–6796 ft. The Cocino (equivalent of Tensleep and Weber) had oil-stained sand between 6842 and 7138 ft, and dolomite and sand between 7873 and 7997 ft, where there was further evidence of water-flushing.

Coring was done on the Rico-Supai and Upper Hermosa formations. Fractured limestone with signs of oil was met at 8779–8791 ft, and 175 b.d. of 14° oil was swabbed in a five-day test. Coring continued to 8857 ft, with loss of 10,000 brl of water. On swabbing, much water with 5% oil was recovered. After squeezing and perforating, sixty days of continuous pumping gave about 30,000 brl of fluid with an average of 25% oil. After placing a plastic plug in twenty-eight days 14,000 brl of liquid, averaging 90% oil, was recovered by pumping.

Electric logs and a map are included. G. D. H.

667. Deepest well confirms theories of regional conditions. C. J. Deegan. *Oil Gas J.*, 11.8.49, **48** (14), 56.—The 20,521-ft well in Sublette County, southwest Wyoming, only reached the Frontier sand. Geophysics had indicated 30,000–40,000 ft of sediments in the Wind River Mountain area where there may be an overthrust to the south and west. There is 7600 ft of Wasatch (Tertiary) in the well; Fort Union–Lance occurred from 7600 to 10,740 ft. The latter may be transitional beds. The definitely Cretaceous Lewis shale was met at 10,740 ft, and a normal sequence of Mesaverde, Blair, Baxter, and Frontier followed. The Wasatch was 50% thicker than expected. The Tertiary had little limestone or dolomite; it had occasional coal and bentonite streaks. Lignites were recorded in the Lewis and Mesaverde. Seven Mesaverde cores and one from the Blair showed signs of oil and gas. Twelve of the seventeen formation tests had slight indications of gas.

Brief notes are given on the cores and formation tests, and there is a generalized graphic log. G. D. H.

668. Highest barrel-per-acre recovery in the Rocky Mountain area. R. F. Carlson. *Oil Gas J.*, 25.8.49, **48** (16), 111.—Lost Soldier in Sweetwater County, Wyoming, has 2200 ft of productive closure and eight separate pays. It has given 39,267,000 brl of oil, or 60,000 brl/acre of the shallower productive area. Most of the pays have active water drive, and a future recovery of 150 million brl has been suggested. Half the wells are pumped, and gas-lift has been employed for nearly twenty-five years.

The Tensleep axis runs northwest–southeast, and is about 2 miles long, the field breadth being about 1 mile. The northeast flank is the steeper. Cretaceous to

Mississippian and Cambrian beds are present. Production from the Wall Creek sands totals about 5 million brl. These are met at 265 ft, and are 200 ft thick. Two Cambrian wells produce at 1750 b.d. The Dakota, Lakota, Morrison, Sundance, Tensleep, and Madison also produce. The Sundance has given nearly 9 million brl, and the Tensleep 16 million brl. Pressure maintenance is applied in the Tensleep. Tensleep porosities average 10–15%, and permeabilities are up to 150 mD. The average thickness is 360 ft. The saturation pressure was 900 p.s.i., although the initial formation pressure was over 2000 p.s.i. The Madison has given 1,575,000 brl. Production occurs at about 5000 ft.

The Cambrian oil is thought to have migrated from younger beds. G. D. H.

669. Canadian discoveries cause search for oil in Dakotas. Anon. *World Oil*, Jan. 1950, **130** (1), 28.—Recent Canadian discoveries in Western Canada and in Manitoba and Saskatchewan have encouraged exploration in the North Central states, where there are several important basins which may hold substantial oil and gas reserves. Exploration is centred in the area east of the Williston basin in North Dakota. C. A. F.

670. Royalite plans Pacific test. Anon. *World Oil*, Nov. 1949, **129** (8), 288.—Preliminary work has shown oil and gas possibilities on Graham Island, off the west coast of British Columbia. A wildcat is to be drilled north of Queen Charlotte, to test the Lower Cretaceous and Jurassic. There are numerous surface oil indications, and an early test found showings of oil and gas. Geological conditions are said to be similar to those of the Mexican Tampico district. C. A. F.

671. Canada's deepest producer is largest gasser. C. J. Deegan. *Oil Gas J.*, 25.8.49, **48** (16), 161.—1 Walter Marr on the Pincher Creek structure has tested 83 million cu. ft. of gas per day, with about 3000 b.d. of 52·5° distillate, at 12,473 ft. Whether it is on a local high, or is a 7-mile-northwest extension of the 1 Pincher Creek discovery is unknown. The discovery showed gas-condensate in the Madison at about 12,000 ft. G. D. H.

672. The Western Canada sedimentary basin area. T. A. Link. *World Oil*, Dec. 1949, **129** (9), 230.—The basin covers approx 800,000 sq. miles, and lies between the Pre-Cambrian Shield and the Cordilleran Mountain area. The contained sediments range from Tertiary to Cambrian, and are gently dipping, averaging 5000 ft in thickness.

The Tertiary is non-marine, and consists of barren sandstones and conglomerates. The Upper Cretaceous thickens to the west and southwest, and consists of marine and brackish sandstones interfingering with dark shale. Basal, lenticular sands are gas bearing. The Lower Cretaceous is oil and gas bearing in small lenticular sands, and includes the extensive Athabaska Tar Sands at the base. Reserves are large. In the Jurassic, oil and gas are produced from sands at the top and bottom of a thick shale sequence. No oil is produced from the Trias, Permian, and Pennsylvanian, but there are shows in the Trias in the Peace River area. The Permian and Pennsylvanian are restricted to the Rocky Mountain area. Oil is produced from Mississippian limestones and dolomites at Turner Valley. Middle and Upper Devonian are present throughout the basin, and hold the greatest reserves. Much Devonian oil is produced from reefs in a limestone–dolomite sequence. No commercial oil has been found in the Silurian, Ordovician, or Cambrian. Oil seeps occur in Pre-Cambrian dolomites, limestones, and argillites at Waterton Lakes Park. Oil has presumably migrated from younger beds via faults.

Structurally, the basin can be divided into areas of gentle dip; the Moose Jaw Syncline, Sweet Grass Arch, Alberta Syncline, and the Great Bear Slave Lake Basin, and highly folded areas: the Foothills, Rocky Mountains, Pre-Cambrian (igneous and sedimentary), Pacific Coast batholith, and the Mackenzie Mountain Salient.

Seventeen maps and cross-sections illustrate the stratigraphy and structure of the basin and the important fields. C. A. F.

673. Tempo increases in Alaskan operations. Anon. *World Oil*, Jan. 1950, **130** (1), 220.—There are good prospects of finding commercial oil in the U.S. Naval Petroleum Reserve No. 4 in Northern Alaska. Oil showings have been recorded in most wells drilled, and a well drilled in the Umiat area made 15 b.d. on test. The Fish Creek well

drilled to 7020 ft, and found good showings in the Upper Cretaceous. Operations in 1949 proved faulting in the Simpson area, where the structures trend east–west.

The present exploratory programme includes the drilling of four test wells, and eleven core holes in the Simpson oil seeps. Further geophysical and geological exploration is planned. C. A. F.

674. Alberta's Golden Spike field given its second producer. Anon. *World Oil*, Jan. 1950, **130** (1), 222.—Golden Spike 4, the second producer in the field, found 560 ft of D_3 pay and produced 2712 b.d. before acidization. The productive area of the field is believed to be approx 1 sq. mile, with reserves of approx 50 million brl.

A well drilled at Excelsior, 12 miles north of Edmonton, found no production in the D_3, but produced 792 b.d. from the D_2. C. A. F.

675. Oil shows are reported in Alberta's Peace River area. Anon. *World Oil*, Nov. 1949, **129** (8), 290.—Normandville 1, 30 miles south of Peace River, flowed 28° oil from approx 6700 ft, on testing a 16-ft Devonian sand. Good oil shows were found in the Madison Limestone. C. A. F.

676. Gas prospects in northern Alberta. A. W. Nauss. *World Oil*, Dec. 1949, **129** (9), 270.—Large reserves of gas north of Leduc have not been developed. Commercial gas has been found in the Viking Sand, the Lower Cretaceous, Madison, and the D_1, D_2, and D_3. The Viking and Lower Cretaceous accumulations are in stratigraphical traps, in sands which pinch out to the northeast. Madison and Devonian accumulations are in limestones which also pinch out to the northeast. C. A. F.

677. New offshore gas field discovery. Anon. *Oil Gas J.*, 19.5.49, **48** (2), 315.—18 miles off Vermilion Parish, southwest of March Island, a well has tested 7,587,000 cu. ft. of gas per day with a spray of 46·7° oil from 7415–7430 ft. G. D. H.

678. Success promised in first foreign venture by CIMA. Anon. *World Oil*, Jan. 1950, **130** (1), 224.—Tortuguero 1, east of Coatzacoalcos (Mexico), found 12 ft of oil sand at 4052 ft, and flowed 48 brl/hr on test. The well is on land, but is testing an offshore structure by directional drilling. Geophysical evidence suggests that the structure is a salt dome. C. A. F.

679. Argentina explores for oil at southern tip of continent. Anon. *World Oil*, Jan. 1950, **130** (1), 222.—Geological and geophysical reconnaissance has indicated that extensive oil reserves may exist in the Tierra del Fuego area. An extensive exploratory programme is planned. C. A. F.

680. Northeastern France discovery is reported. Anon. *Oil Gas J.*, 18.8.49, **48** (15), 87.—In the Soultz-sous-Forets area an oil discovery is reported at 2840 ft in the Muschelkalk, probably not on an extension of the Pechelbronn field. G. D. H.

681. New Emsland discovery considered promising. Anon. *Oil Gas J.*, 12.5.49, **48** (1), 60.—A few miles northwest of Lingen a wildcat, Ruehlertwist 2, found the Bentheimer sand to be oil impregnated. This sand will be tested. It is regarded as being on the prolongation of the Coevoorden–Schoonebeek structure. G. D. H.

682. Emsland continues as most promising area in Germany. Anon. *World Oil*, Jan. 1950, **130** (1), 224.—Suderbruch 1, 2 miles north of the Georgsdorf field, found the Bentheim Sandstone at 3670 ft and produced approx 500 b.d. on test. Oil comes from a stratigraphical trap, a feature not found hitherto in the Emsland area. C. A. F.

683. German discovery has 290-brl initial output. Anon. *Oil Gas J.*, 28.7.49, **48** (12), 179.—Ruehlertwist 2, near the Dutch border, is reported to be capable of pumping 290 b.d. Meldorf 81, between Hemmingstedt and Meldorf, has opened a new producing section, giving 125–155 b.d. from 4350 ft. Werrabronn 3, on the edge of the Weingarten field, gave 35 b.d. initially. Georgesdorf 100 has extended the field 700 m to the west, and gives 14–155 b.d. from 3200 ft. G. D. H.

684. Suderbruch oil discovery at rate of 525 brl. Anon. *Oil Gas J.*, 1.9.49, **48** (17), 32.—1 Suderbruch found oil in the Cornbrash at 6400 ft. It gave 525 b.d. on a $\frac{1}{8}$-in choke, with a gas/oil ratio of 85.

In structural drilling near Quakenbrueck a gas pocket has been found at 720 ft.

Well 94 at Georgsdorf has found edgewater on the southern flank. 1 Dalum-West to the northeast of Georgsdorf and between the Lingen and Adorf fields, appears to be non-commercial.

A 250-brl discovery was reported at 6600 ft near Osnabrueck. G. D. H.

685. A.G.I.P. adds two producers in Po Valley, asks state monopoly. Anon. *Oil Gas J.*, 25.8.49, **48** (16), 85.—Cortemaggiore No. 2 showed some light oil, and No. 3 drilled to 5200 ft and No. 4 to 5850 ft added about 180 b.d. of production. The centre of the field is believed to be towards Cremona. G. D. H.

686. Exploratory work still under way in western Pakistan. J. Coates. *Oil Gas J.*, 19.5.49, **48** (2), 174.—The oil indications of west Pakistan are in a belt of Tertiary rocks which runs northeast from Karachi towards the foot of the Himalayas. To the southeast are extensive areas of alluvium, and to the northwest folded and fractured older rocks. The folds in the Tertiary belt range from overthrust to very gentle folds near the plains. Shows occur in the Cretaceous as well as in the Middle Eocene. Three small fields have been found : Khaur (1915), Dhulian (1934), and Chakwal (Joya Mair and Balkassar) in 1944. In the Joya Mair sector oil has been found in Cambrian beds.

A test was drilled at Khairpur where there is a gas show. The Mekran coast has gas shows and mud volcanoes.

Geophysical surveys in the alluvial plains have indicated that over much of the area there are signs of closed structure. G. D. H.

687. Stepout of Chakwal field gives Pakistan a promising producer. Anon. *Oil Gas J.*, 14.7.49, **47** (10), 58.—A stepout of the Chakwal field has produced oil at 112 b.d. In Feb. Pakistan's output was reported to be about 1900 b.d.

A wildcat at Lakhra, northeast of Karachi, has had gas shows at 6350 ft (minor) and at 8250 ft. G. D. H.

688. Australian report : oil search continues. D. M. Duff. *Oil Gas J.*, 18.8.49, **48** (15), 88.—During fifty years a number of wells have been drilled in Australia, but the oil thus obtained is less than 10 b.d., from Lakes Entrance in Victoria. Production is from a glauconitic sand. There is practically no gas with oil. Several hundred barrels of shale oil are produced daily at Glen Davis in New South Wales. In 1948 a 3256-ft well was drilled at Kopperamanna, northwest of Lake Frome. Aerial photography is planned, and geophysical work has been done. The government has assisted the exploration, and one well was taken to 7300 ft. New interest is being taken in the Cape Range anticline of the Northwest basin ; and a deep well is planned. Closure of over 500 ft is indicated. The Rough Range anticline is believed to have 400 ft of closure.

The Nerrima well in the Desert basin was drilled to 4271 ft before the war. In the Warrinalla area, 105 miles north of Roma, a deep test is planned. A water well at Roma found natural gas at 3683 ft in 1900, and supplied gas to Roma. 90 miles to the north a well had a large flow of gas, mainly carbon dioxide. G. D. H.

Geophysics and Geochemical Prospecting.

689. The four types of petroleum hydrocarbons in drill holes. O. E. Campbell. *World Oil*, Jan. 1950, **130** (1), 72.—Fluorologging provides a record of petroleum hydrocarbons in boreholes. Fluorologs of producers, edge-wells, and wells more distant from the accumulation show that the hydrocarbon curve of the borehole is characteristic of its position relative to the accumulation. A producer shows a low hydrocarbon curve at the top of the hole due to mineralization over the accumulation, and a high curve in the lower section below the zone of mineralization. A dry edge-hole shows a high curve from surface to the pay horizon, and an outpost dry hole shows a high curve at the top which fades out at shallow depth. C. A. F.

690. Geophysical surveys and their utilization. B. C. Browne. *Nature*, 1949, **164**, 859.—Summary of a discussion on geophysics held by Section A at the British Association meeting at Newcastle, 1949. A short description is given of gravimeter surveys made over southern England and the Midlands. The results of the survey, expressed in terms of Bouguer anomalies, show that there is a marked chance of finding coal or oil measures in some of the regions investigated. H. C. E.

691. Reef surveying with radioactivity. R. A. Stothart. *World Oil*, Jan. 1950, **130** (1), 61.—Radioactive emanations from cap-rock shales can be detected at the surface. Signals are received, amplified, and recorded at points along a traverse. By running closely spaced traverses, it has been found that changes in the intensity of the emanations reflect subsurface structural conditions. The method has been particularly useful in delineating reef structures. C. A. F.

692. Telluric prospecting methods. S. Wyrobek. *Nafta*, July–Aug 1948, **4**, 241–6.—Discusses the possibility of using telluric electric currents (discovered in 1947) for geological prospecting. After a short outline of these currents and their diurnal variations in terrain of uniform geological structure he describes the distortions of their regular shapes caused by all sorts of formations. On the whole this method is suitable for sedimentary deposits especially if they do not cut the surface. For this reason it is superior to the gravimetric method. References are given to M. Schlumberg (*Trans. Amer. Geophys. Union*, 20th Annual Meeting 1939) and Boissonnas and L. Migaux of France. M. S.

693. Patent. G. Herzog, assr to The Texas Co., U.S.P. 2,493,346, 3.1.50.—Well-logging detector calibration which comprises passing through a borehole means for detecting variations in the natural γ-radioactivity of the formations around the borehole. C. F. S.

Drilling.

694. Problems of the dynamics of elastic rotating drilling column. M. Gawlinski. *Nafta*, Sept. 1948, Oct.–Nov. 1948, **4**, 287–92, 325–7.—This paper is based on the work of S. Timoszenko-Huber "Lectures on strength of materials" Lvov 1921. Author analyses shapes assumed by suspended freely-rotating drilling column first without and later including friction against walls of the well. Three kinds of elastic equilibrium exist: (1) two-dimensional sinusoidal, or (2) three-dimensional spiral, or (3) variable and unstable as likely to be two- or three-dimensional.

On the basis of above stresses are calculated. M. S.

695. Patent. E. B. Williams, U.S.P. 2,493,178, 3.1.50. Drill bit. C. F. S.

Production.

696. Summary of methods of estimating reserves. A. Houpert. *Rev. Inst. franç. Pétrole*, Oct. 1949, **4** (10), 555–65.—Oil and gas reserves fall into a number of categories: proved drilled reserves, proved undrilled reserves, possible discovered reserves, possible undiscovered reserves, and hypothetical reserves. These depend on the satisfaction of varying numbers of the following conditions: presence of certain sedimentary formations, favourable structure, possibility of oil impregnation, and permeability of the rock. Hypothetical reserves cannot be estimated. Possible undiscovered reserves can be evaluated by comparison with results in areas with similar conditions. Possible discovered reserves can be estimated much more precisely, because the results of secondary recovery can be assessed reasonably well, while reserves in extensions should be capable of assessment more accurately than undiscovered reserves using a recovery per hectare.

$R = Hr_f$, where R is the recoverable reserve, H the oil in place, and r_f the recovery factor. The recoverable reserve is also the cumulative production corresponding to a

limiting economic producing rate of Q_g. The time to which the reserve figure is related must be defined.

The oil in place is calc from the volume of the oil zone, the porosity, interstitial water content, and the volume factor. Ideally, allowance should be made for variations in porosity, saturation, and pressure. Clearly detailed data are necessary for satisfactory results. The saturation method fails more or less when data are few, and particularly in limestone reservoirs. The material-balance method must then be applied, and this should be used to check the saturation method. Basically change in fluid content is related to change in pressure, isothermal conditions being assumed. However, the equation of state of a complex mixture is not always known, and there may not always be equilibrium at each stage in any change. When there is no change in volume of the reservoir and no initial gas cap, a single time period will give enough data to solve the equations. When water advances some oil may be cut off from access to wells. The material-balance method can be used in the absence of data on porosity and on the gas/oil level.

The recovery factor involves a number of features which depend on the operator. The rate of production–cumulative production relationship is not independent of operating conditions, and thus the recovery factor is similarly affected. Some features controlled by the operator (spacing, well dia, tubing) are not easily changed; others can be varied quickly within limits. Above all, the process of drainage is important. The recovery factor for dissolved-gas drive is 10–40%, for water drive 60–80%, and for gas drive 30–80%. At times a decision must be made as to which mechanism shall be allowed to be dominant in the operations.

Decline curves can be employed to estimate reserves by extrapolation to min economic rates of production. These, however, depend on constancy of external conditions, and operating conditions in many fields render application of this method difficult.

In condensate reservoirs recovery factors depend not only on operating conditions but also on permeability distribution.

Sandstones with permeabilities below 1 mD are not of commercial value, but a limestone with a permeability less than 0·1 mD and porosity below 4% can be a good producer. Uncertainty about pressure build-ups may make material-balance studies difficult. G. D. H.

697. Introduction to induction logging and application to logging of wells drilled with oil-base mud. H. G. Doll. *Petrol. Tech.*, June 1949, **1** (6), *A.I.M.M.E. Tech. Pub. No.* 2641, 148–62.—In induction logging the conductivity of the strata penetrated by a well is measured by a coil system which is coupled with the ground by induction. Hence there is no need for direct contact with the mud or with the formations, a feature which allows logging to be done in oil-base mud. The principle of the apparatus is described, and the contribution of each region of the ground in the vicinity of the coil system is discussed. It is shown that the total signal is the sum of a series of products of a geometrical factor and conductivity for each of the regions of the ground under consideration. Thus it is possible to establish for each type of coil arrangement investigation characteristic as well as departure curves and correction charts for beds of various thicknesses. These should facilitate the quantitative interpretation of the logs, even where interpretation would have been difficult using the ordinary electrode system.

Focusing combinations of coils can be used, which give directly on the logs values close to the true conductivities even for fairly thin beds. This eliminates the need for corrections in most cases. Focusing also gives sharper definition of the boundaries between successive strata.

Various charts and diagrams show investigation characteristics, geometrical factors, computed induction logs, departure curves, and corrections for finite thickness and mud invasion. G. D. H.

698. Some theoretical aspects of cycling. M. Muskat. *Oil Gas J.*, 19.1.50, **48** (37), 55.—Among theoretical aspects of cycling are discussed, general features of cycling patterns, the problem of permeability non-uniformity, retrograde condensation at well bores, and the differential depletion in condensate reservoirs associated with permeability stratification.

Seven figures and a number of equations illustrate the article. G. A. C.

699. Behaviour of binary, ternary and multicomponent systems at states similar to those encountered in condensate fields. B. H. Sage and W. N. Lacey. *Petrol. Tech.*, June 1949, **1** (6), *A.I.M.M.E. Tech. Pub. No.* 2631, 143–7.—A growing volume of experimental data on the volumetric and phase behaviour of binary and ternary hydrocarbon systems is used as a basis for comparing these systems with naturally occurring hydrocarbon mixtures under conditions representative of underground reservoirs. Binary and ternary hydrocarbon systems, methane–water, and ethane–water systems are discussed. The qualitative and semi-quantitative similarities and differences between the two types of systems are considered with reference to the possibilities and limitations of using experimental data on these systems for predicting the volumetric and phase behaviour of naturally occurring hydrocarbon mixtures of low molecular weight. Reference is made to the possible influence on such behaviour of water, hydrogen sulphide, nitrogen, and components of relatively high molecular weight.

G. D. H.

700. Rational control of development of natural gas reservoirs. T. Regula. *Nafta*, Sept. 1948 and Oct.–Nov. 1948, **4**, 292–7 and 328–30 (*lecture given to the Assn of Petroleum Engineers & Technologists* in Krosno on 21.2.48).—Following a historical survey the author mentions four technical considerations entering into controlled development of natural-gas reservoirs: (1) drilling methods; (2) flooding and gas-escape prevention; (3) well preservation; (4) constant examination of wells, fields, and the whole reservoir.

He considers in detail the importance of production pressure and volume, gives formulæ for pressure estimation and quantity of gas produced as

$$Q = c \times [(\text{press at no production})^2 - (\text{press at production rate } Q)^2]^n$$

and stresses the importance of correct pressure measurements. He suggests a method for accurate estimation of this and a formula for frictional fall of pressure in well.

Finally, the author gives a brief description of Polish gas fields, and makes suggestions for their preservation.

M. S.

701. Reservoir performance of a high relief pool. E. P. Burtchaell. *Petrol. Tech.*, July 1949, **1** (7), *A.I.M.M.E. Tech. Pub. No.* 2645, 171–9.—In evaluating the effects of gravity drive in the performance of a high-relief pool the basic material-balance data should be weighted for structural differences in pressure and temp. Relative permeability relationships computed from actual field performance should be used in preference to laboratory data. The oil and gas relative-volume factor must be corrected for gravity segregation effects using actual field-performance data as a guide.

The calculations indicate higher recoveries and lower peak gas/oil ratios for gravity drive than for gas drive.

Details of the method are given, together with relevant tabulations and graphs, but the method is not claimed to be a complete solution of the problem of analysing the reservoir behaviour of a gravity-drive pool.

G. D. H.

702. Oil sands demonstration plant in operation. W. E. Adkins. *World Petrol.*, 1949, **20** (13), 40–5.—Oil-sand deposits on the Athabaska river are being worked on an experimental scale. Mining operations are described. Oil sand costs approx 20 c/ton at the refinery. The sand (50–200 mesh) containing about 15% of visc asphaltic oil (sp. gr. 1·004, S 5%) is mixed with hot water in stages, with agitation and aeration, and settled to give an oil containing 25% water, 4–8% sand. On dilution with approx 30% naphtha and settling, the sand separates, and water is driven off by heating. Dist of the oil produces naphtha (130–457° F, O.N. 67, S 1·3%), intermediate cut, light and heavy gas oil, and flash-tower residue. 75–80% of theoretical oil content of sand is recovered. A flow diagram is given.

E. B.

703. Production of oil under investigation in Wertz Dome field, Wyoming. E. A. Swindenborg. *Petrol. Tech.*, June 1949, **1** (6), *A.I.M.M.E. Tech. Pub. No.* 2588, 163–70.—The Wertz Dome, 88 miles southwest of Casper, first gave gas in 1921, from the Muddy sandstone at 3435 ft. The structure is a sharply folded northwest–southeast anticline, some 3 miles long and 1 mile wide. The Tensleep oil production covers 650 acres; the deeper production may be rather less extensive. The similarity of the oil, gas, and water in the Tensleep, Amsden, Madison, and Cambrian suggests migration

via faults, although no faults are indicated at the surface. The Tensleep production is at 5800–6300 ft; porosity averages 14% and permeability 70 mD; connate water is 10%. The 24° Tensleep producers range 55–8350 b.d. Twenty flow, and the min pressure for flow seems to be about 2000 p.s.i. Tensleep gas is compressed for injection in three stages to 1825 p.s.i., with dehydration between the first and second stages, because the wet gas with 52% CO_2 and 1·1% H_2S is highly corrosive. The plant is semi-automatic.

Since 1942 production has been kept below 6000 b.d. There was no Tensleep gas cap until gas injection was begun. The original gas/oil ratio was 210 cu. ft/brl. Gas from the Cloverly and Sundance is added to Tensleep gas for injection. By the end of 1948 7,043,600,000 cu. ft. of gas had been injected, and the average pressure was then 2140 p.s.i., 190 p.s.i. more than in 1942. The original pressure may have been 2600 p.s.i., and when injection began in 1941 the cumulative output was 3,400,000 brl; at the end of 1947 the cumulative output was 14,410,260 brl. The bulk of the gas injection has been through one crestal well. Gas injection is considered to be highly beneficial.

Graphs and tables provide detailed data on various points. G. D. H.

704. Patent. E. R. Williams, U.S.P. 2,493,095, 3.1.50. An oil and gas separator comprising an upright tank having oil and gas inlets and means for separately discharging oil and gas. C. F. S.

Oilfield Development.

705. World production of 92,600 brl daily in June : upturn seen. D. M. Duff. *Oil Gas J.*, 25.8.49, **48** (16), 86.—World oil production in June 1949 was about 9,090,300 b.d., the U.S.A. giving 4,933,000 b.d. The Soviet-controlled production is believed to be 730,000 b.d. Venezuela averaged 1,290,100 b.d., Colombia 85,600 b.d., Canada 56,000 b.d., Mexico 157,000 b.d., Iran 549,100 b.d., Kuwait 239,500 b.d., and Saudi Arabia 481,100 b.d.

A table gives the May and June outputs by countries. G. D. H.

706. Foreign output up 460,000 brl daily, or 15·9%. D. M. Duff. *Oil Gas J.*, 28.7.49, **48** (12), 199.—Excluding Russia and eastern Europe, oil production outside the U.S.A. in the first half of 1948 averaged 3,379,500 b.d. Kuwait gave 253,300 b.d., 200% more than in the first half of 1949. Iraq averaged 58,900 b.d., a decline of 32·7%. Venezuela gave 1,237,100 b.d. Canada's output was 53,900 b.d., while Colombia gave 83,500 b.d. Trinidad produced 55,000 b.d. and Egypt 42,400 b.d.

A table gives the average daily output, by countries, for the first half of the years 1948 and 1949. G. D. H.

707. First-half production shows drop of 27 million barrels. P. De Armond. *Oil Gas J.*, 28.7.49, **48** (12), 192.—The U.S.A. produced 970,753,000 brl of oil in the first half of 1949; the corresponding figure for 1948 was 998,157,000 brl. The Texas output was 411,324,000 brl, a drop of 33,550,000 brl compared with 1948.

Tables give the production by states and districts for the first half of each year from 1941, and the daily average output per well by states for the first half of 1949.

G. D. H.

708. Footage drilled during 1949 may set new record. C. J. Deegan. *Oil Gas J.*, 28.7.49, **48** (12), 186.—67,172,000 ft was drilled in the U.S.A. in the first half of 1949, and 70,925,000 ft was expected to be drilled in the second half. 18,519 wells were drilled in the first half of the year.

Tables give the forecasts of drilling and footage by states and districts for the second half of 1949, the numbers of wildcats and field wells being shown; the numbers of wildcats drilled in the first half of 1949 and planned for the second half; a comparison of achievements in the first half and plans for the second half of the year.

G. D. H.

709. 18,519 wells, 67 million feet of hole drilled so far this year. J. C. Casper. *Oil Gas J.*, 28.7.49, **48** (12), 189.—In the U.S.A. in the first half of 1949 18,519 wells, aggre-

gating 67,172,000 ft, were completed. There were 3553 wildcats. 10,465 oil wells, 1308 gas wells, 749 service wells, and 5997 dry wells were drilled.

Tables summarize the results of completions in the first half of 1949 by states and districts; similar data are given separately for wildcat and development wells; completions according to depths, and method of drilling; wildcat, development, service, and distillate completions by months. 14,672 rotary wells were completed, 475 wells were in the range 10,000–12,500 ft, and sixty-six were over 12,500 ft deep.

G. D. H.

710. Major fields take brunt of cuts in production. C. J. Deegan. *Oil Gas J.*, 28.7.49, **48** (12), 201.—130 major fields in the U.S.A. gave 460,438,000 brl of oil in the first half of 1949, and 504,628,000 brl in the first half of 1948; the corresponding figures for all other fields were 510,315,000 brl and 493,529,000 brl.

Tables list the major fields with their discovery date, expected ultimate, remaining reserves at the beginning of July 1949, cumulative production during the first half of 1948 and 1949, and the age and nature of the main producing horizon; the production of the major fields and of the other fields by states for the first half of 1948 and 1949.

Major fields are defined as those with ultimates exceeding 100 million brl.

G. D. H.

711. Gain in Venezuela boosts world production above April figure. D. M. Duff. *Oil Gas J.*, 21.7.49, **48** (11), 47.—In May Venezuela produced 1,292,000 b.d., 8% more than in April. Western Venezuela gave 879,832 b.d. The U.S. May production was 4,968,000 b.d., a decline of 44,000 b.d. World production in May was 9,169,500 b.d. Colombia attained a new high of 89,397 b.d. with distillate. The Middle East output averaged 1,417,600 b.d.

A table gives the May output by countries. G. D. H.

712. Czechoslovakia's petroleum outlook. Anon. *Oil Gas J.*, 11.8.49, **48** (14), 60.—Oil and gas seeps have long been known in the much-faulted Flysch area of the Tertiary in east Slovakia, and in the centre of the country. In the 1860s two shafts with horizontal galleries were sunk near Mikova, but these and other shafts gave only small outputs. The Flysch area was first drilled in the 1880s, and subsequently wells up to 3000 ft deep were sunk near Mikova, Vysni Komarnik, Radvane Kriva Olka, Staskova, Bohuslavice and Vlarou, Napajedla, etc. Many of the wells had oil or gas shows, and some production was obtained, the best results being in two Flysch wells near Turzovky in 1929. Gbely, opened in 1914, was the first commercial producer, from the Sarmatian at 535 ft. Hodonin was opened in 1923. Both have given 105,000–140,000 brl/year. The Germans raised output to about 250,000 brl in 1941. The fields were later damaged. Since the war the government has made efforts to develop the oil industry. In 1947 the output was about 245,000 brl, and in 1948 342,000 brl.

Equipment is being manufactured and even exported to Russia. The Brux hydrogenation plant has been repaired, but the oil made from coal is very expensive. In parts of the country motor traffic is largely dependent on natural gas.

About 1200 wells have been drilled, mainly 500–1200 ft deep. Most of them are in the Gbely–Hodonin area. There are a number of prospective structures.

G. D. H.

Transport and Storage.

713. Elk basin area crude-oil pipe line. P. Reed. *Oil Gas J.*, 19.1.50, **48** (37), 50.—The new 67-mile 12-in crude-oil pipeline from Elk basin area to refineries at Billings and Laurel, Mont, is described. The pipeline is solid welded throughout its length.

Full advantage of a 1100-ft drop in elevation is taken, enabling gravity flow at rate of 50–75% of rated capacity, depending on weather conditions.

Bulk of the oil handled is sour crude with a high hydrogen-sulphide content demanding special safety precautions for men going to the tanks. G. A. C.

714. Canal used to move five 55,000-barrel tanks. Anon. *Refiner*, Mar. 1949, **28** (3), 120–1.—The movement of five tanks by floating along prepared canals was chosen because it was considered less expensive and less damaging than either dismantling or

skidding. One tank was moved 1510 feet, requiring 187 man-hours, three bulldozers, and pumping equipment for the whole job. W. E. M.

715. River transportation developments. C. R. Horton, Jr. *World Petrol.*, 1950, **21** (2), 40–3.—Operational problems arising from the use of integrated fleets of barges and the methods of overcoming them are discussed. Aspects considered are steering design in towboats, effects of integration on flexibility of tows and of different types of barge integration on speed and ratio of power to displacement. Pumping facilities on barges and wharves are also dealt with. Figures are given showing effect of tow speed and currents on operating costs, these are min at approx 5 m.p.h. in still water. E. B.

716. Effect of thermal expansion on capacity of large vertical storage tanks. W. E. Splain. *Petrol. Process.*, 1949, **4**, 665–6.—The change in tank capacity due to thermal expansion and contraction of the tank itself is discussed. The effect is shown to be appreciable for accurate measurements, particularly in large-dia tanks. The effect on storage inventory is accumulative and seasonal. Temp-correction factors are given for the accurate measurement of volume. W. E. M.

717. Patent. J. C. Munday, assr to S.O.D. Co., U.S.P. 2,493,544, 3.1.50. Stabilization during storage of commercial xylidine against discolorization. C. F. S.

Refinery Operations.

Refineries and Auxiliary Refinery Plant.

718. Refineries and auxiliary refining plant. Burrel gasoline plant extracting 80% propane. M. E. Garrison. *Refiner*, Mar. 1949, **28** (3), 153–62.—The Burrel gasoline plant operated by General Petroleum Corp. is described in detail. Several new and interesting innovations are included in the plant. A plant lay-out diagram is given, and flow sheets of the absorption plant, the propane-cooling plant, and the fractionation equipment are included. Detailed material-flow balances are shown. W. E. M.

719. Unique operating units at "Conoco's" Billings plant. Anon. *Refiner*, Apr. 1949, **28** (4), 126–9.—The refinery was designed to handle particularly sour crudes of low gravity. All light oils (through 600° end-point gas oil) pass as vapour to a desulphurizing catalytic reactor. The desulphurizer operates at 700° F, and the powdered catalyst is regenerated in a vessel designed primarily for the spent catalyst from the conventional cracking reactor. The light-oil portion of the crude is approx 47% of the charge. W. E. M.

720. Possibility of manufacturing in France certain aviation gasoline components. (Technical *iso*pentane and *iso*octane). P. A. Laurent. *Rev. Inst. franç. Pétrole*, 1949, **4**, 671–4.—Compagnie Française de Raffinage operates at Gonfreville a superfractionation unit from which 15,000 tons/year of *iso*pentane can be obtained. Tower utilized for final separation of *n*-pentane and *iso*pentane is 38 m high, 2·3 m dia, and operates at 1·5 kg/cm² with a R.F.R. of 12/1. Product averages a purity of 96%, this is verified by infra-red analysis. Plant instrumentation is described. *iso*Octane (planned capacity approx 10,000 tons/year) will be obtained from Martigues where *iso*butylene/butylene are co-polymerized in a phosphoric acid cat unit. Subsequent hydrogenation is to be carried out elsewhere. V. B.

721. New uses for aluminium. B. J. Fletcher. *Petrol. Process.*, 1949, **4**, 1105–8.—The application of Al and Al alloys in the petroleum industry are reviewed. Use of alloys in tank-roof and top-shell rings tends to resist corrosion by sour crudes. Other suggested uses include: pipelines, heat-exchanger tubes, special corrosion-resisting clad tubes, insulation covering; and, in the cathodic protection of buried pipelines, galvanic aluminium anodes have been used. W. E. M.

722. Conversion of atmospheric cooling tower to induced-draft operation. R. Todd. *Oil Gas J.*, 5.1.50, **48** (35), 46.—Details of conversion of a twenty-nine-bay atm-type cooling tower to induced-draught operation at the Goleta gas-storage field, Santa Barbara, California are given.

The requirements for the unit are discussed, several types being considered. Only one-half of the tower could be converted at a time, and total cost, including electrical installations, amounts to approximately $58,275. G. A. C.

723. How to test and maintain cooling towers. H. R. Baker and G. T. Long. *Chem. Ind.*, Dec. 1949, **65** (5), 892.—The growth of chemical industry has placed a strain on the fresh-water supplies in certain areas in America. To conserve these supplies, the efficient function of cooling-towers is essential, and, to realize this efficiency, it is necessary to carry out frequent checks on their performance. A suggested procedure for these operations can be outlined as follows : (1) clean out and inspect cooling-tower (this includes the checking of mechanical equipment, water-systems, and structure); (2) determine design requirements from contract papers ; (3) measure water quantity ; (4) check water temps ; (5) determine wet-bulb temp of air entering the tower.

The figures obtained from the above measurements should be compared with design figures.

Of these determinations, the most difficult is (3). Suggested approaches are through circulating-pump performance, or through heat balance. O. M.

724. Automatic package units for dehydration. A. W. Francis and J. L. Maher. *Oil Gas J.*, 5.1.50, **48** (35), 70.—Principal requirements for and factors determining capacity of package units for gas dehydration are discussed. Among requirements are listed portability, ease of erection, free of outside facilities, automatic operation, ease of maintenance, and operation and safety.

Regarding capacity, this is a function of the water content of the gas, the type of desiccant in service, temp of the gas in contact with desiccant, and the relative humidity of that gas.

A figure shows effect of pressure and temp on the volumetric capacity of a solid-desiccant plant. G. A. C.

725. Expansion problems in heat insulation of process vessels. E. R. Sitton. *Refiner*, Feb. 1949, **28** (2), 131–5.—The problem of mechanical design of heat insulation is discussed with special reference to the avoidance of cracking through inadequate provision for thermal expansion. W. E. M.

726. Hydrogen blistering of steel.—A source of damage to vessels. M. H. Bartz and C. E. Rawlins. *Petrol. Process.*, 1949, **4**, 898–906.—The cause of blistering of vessel walls and other refinery equipment is shown to be the attack of atomic hydrogen released by the acid corrosion of the steel. This same condition may lead to embrittlement of the steel, particularly at high temp. Use of corrosion-resistant linings has been adopted. Location of blisters before numerous or large cracks appear can prevent the onset of serious failures. Several " case histories " are reported from a wide variety of sources in the petroleum industry. W. E. M.

727. Investigation of the influence of pipe diameter and lay-out on the hydraulic resistance and nature of flow of a gas–liquid mixture. S. I. Kosterin. *Izvest. Akad. Nauk S.S.S.R.; Otdel. Tekh. Nauk.*, 1949, 1824–31.—Tests were carried out in horizontal steel tubes 15 m long having dia 25, 50, 75, and 100 mm, and also in vertical and inclined (72°) tubes of 25 mm dia. Hydraulic resistance coeff variation in Froude No. range 0·1–1000 was investigated for a wide range of gas contents. When latter is high, gas compressibility is an important factor, and resistance coeff in horizontal tubes may vary by 20–80% from that for a single-phase fluid. With increasing gas content from 0 to 90% the resistance coeff first rises to a max and then falls. Examination of the nature of the flow of gas/liq (air/water) mixtures shows this to vary with increasing rate of flow from the distinct separate flow of the two components to the flow of an almost homogeneous foam. Diagrams are given showing the nature of the flow for various gas contents and velocities at the various tube dia investigated, and photographs showing appearance of mixtures are reproduced. At flow rates, 3 m/sec

position of pipe (*i.e.*, horizontal, vertical, or inclined) affects nature of flow, but at higher velocities this influence disappears. V. B.

728. Transmission piping for refinery steam system. T. G. Hicks. *Refiner*, 1949, **28**. Part 1 Apr. (4), 135–8. Part 2 June (6), 103–8. Part 3 July (7), 143–5.—An attempt is made to evolve a standardized procedure for the design of efficient and economical refinery steam-transmission lines, taking into account the many important factors—pressure loss, pipe size, pipe-wall thickness, pipeline heat losses, pipeline expansion, and condensate removal and return. Nomographs are given for the calculation of pressure losses and for determining terminal pressure of steam-pipes operating at the critical velocity. Data are also given for the allowable stress values for pipe in steam-transmission lines.

Part 2 deals with the methods of absorbing thermal expansion of steam pipes: (1) expansion U-bends; (2) double-offset expansion U-bends; (3) slip joints; (4) expansion bends composed of welding elbows. For methods 1 and 2 data are given for allowable distance between anchors and for anchor reactions. All four methods are discussed and compared.

In Part 3 the problems of materials and costs are discussed. The four types of steam-line discussed in Part 2 are again compared, and a calculation of optimum line dia is presented. W. E. M.

729. Flocculation. A method for conditioning refinery effluent for re-use, disposal. F. M. Faulconer, D. L. McCann, and H. L. Bedell. *Petrol. Process.*, 1949, **4**, 656–9.—A scheme is presented for the partial conditioning of petroleum-refining effluent for re-use and disposal. In the recirculation of water within the plant, a higher concentration of dissolved solids is permitted so that the total effluent which must be eliminated from the plant is reduced to a min. This effluent is finally treated to remove all traces of oil and most of the other contaminants. The water has little odour and generally a good appearance, and has no bad effects on local surface drainage. The application of the method in a skimming and cracking plant is described. W. E. M.

730. Oil separator for waste water disposal. G. E. King. *Refiner*, Apr. 1949, **28** (4), 117–23.—The development and operating conditions of a separator designed to handle up to 45,000 g.p.m. of waste-water and rain-water are fully described. The recommended A.P.I. pattern was followed closely, except for certain special features. Primary separation of oil and sludge was achieved at relatively high velocities, and a central distribution chamber replaced the influent channel and primary sections of the conventional A.P.I. design. The design of the inlets to the final chambers was an improvement on the A.P.I. front-end design in that the loss-of-head was reduced by 75%. The overhead skimmer and scraper units were also different from the suggested flight skimmers and oil-collecting pipes suggested by the A.P.I. design. Separation is effected in two distinct stages, although the water passes through only one chamber.

Recovery was about 95% of the oil from the waste water. W. E. M.

731. How to increase propane recovery. D. P. Thornton. *Petrol. Process.*, 1949, **4**, 519–24.—The natural gasoline plants at six selected refineries are described, bringing out the features whereby propane recovery has been greatly increased during the last two years. Improvements have been effected by the following main processing techniques: (1) increasing oil circulation; (2) refrigerating the wet gas or the absorber oil, or both; (3) raising absorber operating pressure; (4) reabsorbing residue gas from existing absorbers; (5) stage flashing and recompressing; (6) adding new and/or larger de-ethanizers; (7) increasing other fractionating columns; (8) eliminating bottle necks. W. E. M.

732. Short cut process design to increase propane recovery in gasoline plants.—Multi-stage distillation. A. S. Glendening and C. F. Sanderson. *Petrol. Process.*, 1949, **4**, 530–4, 667–70.—High-recovery gasoline plants using the conventional absorption oil-distillation system often require excessively large gas-surge tanks. It is shown that an alternative scheme employing multi-stage distillation makes possible the operation of the surge tank at a much higher operating pressure. A set of calculations are presented which show that a 25-b.h.p. recompressor is satisfactory in a hypothetical plant

using multi-stage distillation, although the same plant would require a 300-b.h.p. recompressor if conventional single-stage distillation were used. W. E. M.

733. Short cut process design to increase propane recovery in gasoline plants.—Gas fractionation. A. S. Glendening and C. F. Sanderson. *Petrol. Process.*, 1949, **4**, 893–7; 999–1002.—The process of gas fractionation as applied to natural gasoline plants is discussed. Flow diagrams are given, and the effect of various operating variables discussed. Methods of calculation for the design of gas-fractionation facilities are presented. W. E. M.

734. Refrigeration–compression system boosts propane recovery to 70%. W. Swerdloff. *Petrol. Process.*, 1949, **4**, 993–7.—The refrigeration–compression process is used in Magnolia Petroleum Co.'s plant at Kilgore, Texas, because the rich-inlet-gas rate fluctuates widely. The change-over from gas rectification, previously employed, is described, showing that only additional heat exchangers, dehydration and refrigeration units, and a raw-gasoline surge tank were required. The propane recovery was increased from 40 to 70%. W. E. M.

735. Patents. E. G. Scheibel, assr to Hoffman–La Roche Inc., U.S.P. 2,493,265, 3.1.50. A countercurrent liquid-extraction apparatus with transverse calming sections and mixing sections. Wire-mesh packing is used as the separator material, and propeller agitators mounted on a vertical rotating shaft.

L. F. Strader, assr to Houdry Process Corporation, U.S.P. 2,493,784, 10.1.50. Catalyst regeneration apparatus. C. F. S.

Distillation.

736. Toluene plant converted to gasoline stabilization with little alteration. Anon. *Oil Gas J.*, 2.2.50, **48** (39), 70.—The wartime toluene plant at the Oleum refinery of Union Oil Co., California, has been converted to a complete gasoline-stabilization plant with a daily capacity of 10,000 brl of full-range 400° E.P. gasoline as the charge stock. Butane and lighter fractions are removed, a $C_5$300 E.P. gasoline as overhead is cut in one column with a heavy gasoline as bottoms.

A process flow diagram of light-ends unit is shown. G. A. C.

737. Twin naphtha-rerun units at El Segundo refinery. R. Harwick. *Oil Gas J.*, 5.1.50, **48** (35), 55.—The two new naphtha re-run units of the Standard Oil Co., California, in operation at El Segundo refinery are briefly described.

Rated capacity is 11,000 b.d. per unit, feed is cracked, treated naphtha, producing one, two, or three gasoline streams, and one of gas oil. G. A. C.

738. Instrumentation for light ends fractionation. E. L. Stark. *Oil Gas J.*, 19.1.50, **48** (37), 62.—Temp pressure and reflux controls for a four-column light-ends fractionation plant are discussed. An actual instrument installation and application is charted, and a table gives operating data on fractionating vessels.

Most recorders are operated by pneumatic transmitters, thus no hazardous fluids are brought into the control-room, and flow meters are installed at points in best relation to their orifices. G. A. C.

739. Simplified multicomponent fractionation calculations. R. V. Bailey and J. Coates. *Refiner*, Feb. 1949, **28** (2), 123–9.—Methods of determining the distribution of components intermediate between the key components, with a min of trial and error, are presented. A simplified method for conditions of min reflux using the Underwood equations cannot be used for the case of varying relative volatilities. A simplified method of applying the Colburn relation at min reflux to the determination of the distribution of split-key components is presented. A study has been made of the distribution of split keys which will give the optimum number of trays at all reflux ratios except those very close to the min. W. E. M.

740. Patents. H. V. Hess, assr to The Texas Co., U.S.P. 2,493,537, 3.1.50. The azeotropic distillation of hydrocarbons with sulphur dioxide, by separately heating the

hydrocarbons and the SO_2 and then contacting the two at a temperature above polysulphone formation temperature, and conducting azeotropic distillation at temperatures in excess of such temperature.

S. F. Birch, J. Habeshaw, and C. B. Collis, assrs to Anglo-Iranian Oil Co., U.S.P. 2,493,567, 3.1.50. The preparation by distillation of a pure hydrocarbon from a feedstock consisting of *n*-hexane, benzene, methyl*cyclo*pentane, *cyclo*hexane, and 2 : 2- and 2 : 4-dimethylpentanes. C. F. S.

Absorption and Adsorption.

741. Carthage completes largest gas treating plant. H. D. McLean. *World Petrol.*, 1949, **20** (13), 34–6.—General description is given of plant designed for processing gas from over 73,800 acres of gas-producing leases. Seven absorbers 5½ ft dia, 72 ft high are installed. Rich oil is processed to give gas, C_3H_8, C_4H_{10}, controlled F.B.P. and v.p. motor gasoline, naphtha, kerosine, and heavier products. A liq-desiccant system reduces moisture in the gas to 4 lb/million cu. ft. Heating is by a large Dowthern "A" unit. Air condensers are extensively used. E. B.

742. Garvin county gas plants embody new features. Anon. *World Petrol.*, 1949, **20** (13), 30–3.—Plants at this Oklahoma field compress a total of 80 million cu. ft/day gas in three stages. The gas is passed through thirty-tray absorbers, and gasoline, propane, and butanes produced from the joint rich-oil streams. Facilities include distillation, fractionation, storage, and loading, now handling 220,000 gal liq products/day and capable of expansion to 300,000 gal/day. Plant operation and equipment are described, and a flow diagram given. E. B.

743. Joint gas-gathering system and compressor plant for Cymric field. S. H. Lacy and W. H. Kraft. *Oil Gas J.*, 18.1.50, **48** (37), 66.—Application of a single and efficient process flow to the special problem of a rapidly declining plant load, and attention to equipment selection, costs, and lay-out made the installation of a "marginal" gasoline plant in Cymric field, California, an economically sound project.

The plant has to handle 35–40 million cu. ft/day of lean gas, effect max recovery of butanes plus and a relatively high recovery of propane from 15 million cu. ft/day of rich gas, retain 90% of propane recovered at main absorber, and produce either butane–propane mixture or propane as desired.

Tables show main absorber and rectifier-absorber operation, and fuel and steam consumption. G. A. C.

744. Refining by adsorption. S. Eagle and J. W. Scott. *Petrol. Process.*, 1949, **4**, 881–4.—A cyclic-adsorption process for separation of chemical intermediates and special products from petroleum is described. Beds of adsorbent of fine particle size are used, and cyclic operation is obtained by automatically shifting the adsorbent columns counter direction to liq flow. The columns may be packed with silica gel, carbon, or other suitable adsorbent. W. E. M.

745. The influence of the (water) vapour condition on its consumption in natural gasoline (adsorption) plant. K. Szadkowski. *Nafta*, July–Aug. 1948, **4**, 255–88.—Steam used for expulsion of adsorbed natural gasoline provides heat for this operation and carries away gasoline to the condenser. When wet steam under pressure of 165 lb expands and pressure falls to 0·3–0·5 atm. guage expansion follows Molier's graph. The formula used is :

$$P_1V_1^n = P_2V_2^n$$

where

$$n = \frac{K(1+\xi)}{1+K\xi}\ ;\ 0{\cdot}05 < \xi < 0{\cdot}1$$

The author makes a complete heat and material (water and gas) balance for wet and supersaturated steam which shows an economy of over 10% whenever supersaturated steam is used. M. S.

Solvent Extraction and Dewaxing.

746. Treatment of light distillates by the SO_2 extraction process. P. Obergfell. *Petrol. Process.*, 1949, **4**, 660–4.—The latest developments in the Edeleanu process are reviewed, and data derived from pilot-plant and commercial-plant operation are presented. It is suggested that SO_2 treatment of catalytic-cracking recycle stock would remove aromatics and thereby increase the capacity of the plant for fresh feed stocks. W. E. M.

747. The use of propane dewaxing and deasphalting in the Polish petroleum industry. S. Niemientowski. *Nafta*, June 1948, **4**, 227–34; July–Aug. 1949, **4**, 258.—Polish solvent-refining plants have been unable to develop fully due to the war. Only one was built prior to the war in 1933–35.

In 1920 Dr K. Kling of Lvov University worked on solvent refining using C_4 and C_5 at the Research Institute "Metan." In touch with him Dr J. Kozicki tried using petroleum ether. Both tried to find a solvent which would lower the surface tension more efficiently. They used Gibbs's formula

$$\text{increase of concentration at interface} = \frac{-C}{RT} \times \frac{d\sigma}{dc}$$

as their theoretical basis later they used C_3. Their demand for C_3 was satisfied in 1930 by refinery "Gracja," which, using equipment of South Western Co., Los Angelos, provided them with 60–80% pure propane. Large-scale laboratory apparatus was employed Experiments were carried out by J. Kronisch, I. Niemientowska, and the author. Results showed that separation at 30–50° C is fairly complete. Quantity of asphaltenes is proportional to quantity of propane; recovery of propane can be easily effected, and the propane remaining in wax lowers its viscosity. Next a pilot plant was built at Gracja refinery, and its working is described. Cresol–water mix and nitrobenzene were used on oils already freed from petrolatum and asphalt. First full-scale refining unit was built in Jedlicz using old drilling pipes, etc., and immediately gave valuable products. Dewaxing and deasphalting processes are fully described with flow diagrams of equipment. Biggest difficulties seemed to arise out of the fact that this plant, the first of its kind, was intended to be profit making and small changes were difficult to carry out. Plans for a second refining unit were well advanced in 1939. In view of easy availability of C_3 losses of 2–4% for dewaxing and 6–8% for combined dewaxing and deasphalting were of no consequence. Fairly detailed drawings of projected new plant are included. This was intended for throughput of 1000 tons per month. It was planned to deasphalt the oil first, then to refine it with cresol–benzil mixture and H_2O nitrobenzene and then again using C_3 to dewax it. Both processes are well described. After the war the Jedlicz unit was rebuilt and enlarged with small structural changes. American and British technical literature has influenced the planners as well as independent research. M. S.

748. Patent. G. H. Reman, assr to Shell Development Co. U.S.P. 2,493,596, 3.1.50. The improvement in the process for refining mineral lubricating oils by solvent extraction to remove asphaltic impurities, which comprises preceding the solvent extraction by treating with up to about 10% by weight of antimony trichloride as the precipitating agent. C. F. S.

Cracking.

749. Chemistry of cracking catalysts. C. L. Thomas. *Industr. Engng Chem.*, 1949, **41** (11), 2564–73.—Application of the chemistry of silica and alumina in the solid state to the silica–alumina cracking cat has produced a hypothesis that the active part of the cat is formed when one Al atom shares four O_2 atoms which are also shared by four Si atoms. An acidic H ion is thought to be associated with the four O_2 atoms, and is believed to be responsible for the cat activity. The active part of the cat is written $(HAlSiO_4)x$, where x indicates that it is part of a solid which may or may not have the same composition. $(HAlSiO_4)x$ cannot exist as $HAlSiO_4$ (monomer). Hypothesis leads to the conclusion that max activity is produced when atomic ratio of silica

to alumina is one. Special preparations are necessary to obtain max activity. Formation of a silica hydrogel and deposition of alumina upon it is not likely to give max activity. R. G. T.

750. Raw crude oil is charged directly to 2800 b.d. catalytic cracking unit. H. A. Brown and M. J. Sterba. *Petrol. Process.*, 1949, **4**, 878–80.—A catalytic-cracking unit has been run successfully on a mixture of Neiber crude (sour but salt-free) and Wyoming gas oil, without apparent harm to the catalyst. Distillation of the crude, desulphurization of its gasoline, and cracking of the topped crude are accomplished in one step. W. E. M.

751. Catalytic effects in suspensoid cracking. C. H. Caesar. *Petrol. Process.*, 1949, **4**, 887–90.—This paper discusses the fundamental nature of suspensoid cracking. Empirical experiments are described with various feed-stocks under typical operating conditions. It is concluded that the process has features in common with both conventional pyrolytic and catalytic cracking. The distribution of hydrocarbon types in the product tends to be more akin to pyrolytic cracking, though "catalytic reactions" (isomerization, hydrogen transfer, polymerization, and intra-molecular condensations) are shown to take place. W. E. M.

752. Catalytic and thermal cracking of pure hydrocarbons.—Mechanism of reaction. B. S. Greensfelder, H. H. Voge, and G. M. Good. *Industr. Engng Chem.*, 1949, **41** (11), 2573–84.—Study is made of the primary cracking of pure hydrocarbons, with and without cats, in terms of distribution by C number of the cracked fragments. A mechanism of molecular disintegration was sought. Analysis of the fractions produced by the secondary reactions of the cracked fragment allow a further definition of the nature of the cracking system. Two fundamental classes of cracking systems are thus recognized; each is described by a set of characteristic reactions covering both primary and secondary reactions. Two types of mechanism are therefore proposed: one a free radical (thermal-type) mechanism based on Rice–Kossiakoff theory, the other a carbonium ion (acid-activated type) mechanism derived from work of Whitmore and others on the properties of carbonium-ion systems. Cracking cats for both types of mechanism are available—non-acidic for free-radical-type mechanism and acidic for carbonium-ion type mechanism. Synthetic silica–alumina cracking cats and commercial acid-treated clay belong to the second class. A unique product distribution, explained as a quenched free-radical type, is obtained with activated C—a highly active non-acidic cat. Activated alumina has weakly acid properties and moderate catalysis of both types is produced. Primay cracking follows free-radical type, and secondary cracking of product olefins follows carbonium-ion type. R. G. T.

753. Thermal cracking of fluid catalytic cycle gas oils. H. McReynolds and J. M. Barron. *Refiner*, Apr. 1949, **28** (4), 111–16.—The utilization of cycle gas oils produced by fluid catalytic cracking is discussed. The thermal-cracking properties of a large number of such gas oils from a wide variety of crudes have been determined. Correlations are given for yields, product quality, sulphur content, and fresh feed capacity, and comparisons drawn with virgin gas oils of the same gravities. The results tend to show that fluid catalytic cycle gas oils tend to yield more cycle fuel oil and less naphtha and gas than virgin gas oils. O.N.s are less, and the cycle fuel oils have a lower gravity for a given viscosity. W. E. M.

754. Continuous contact coking. A. H. Schutte and W. C. Offutt. *Petrol. Process.*, 1949, **4**, 769–75.—A new method is presented for the conversion of heavy-residuum oils and tars to coke and light oils. Continuous circulation of a stream of hot coke is used. The coke is mixed with the preheated oil charge and falls through a cylindrical reactor where successive layers of coke build up the particles, and those of the desired size are removed as dry lump coke. The coke so produced is of low volatile content and high mechanical strength. The vapours overhead from the reactor form gas, gasoline, and gas oil, and a recycle stock is taken off as bottoms. The circulating coke is raised in the standard pressure-type round-case elevators as used in T.C.C. units. It is claimed that heavier stocks may be processed than in conventional coking plants, and yields of light oil are greater. W. E. M.

755. Patents. C. V. Berger, assr to Universal Oil Products Corporation. U.S.P. 2,492,948, 3.1.50. A method of controlling catalyst regeneration temperature by indirect heat exchange with a cooling fluid during the upward and downward flow of the catalyst particles.

R. E. Bland, assr to Houdry Process Corporation. U.S.P. 2,492,958, 3.1.50. A process which comprises introducing active fluent catalyst to the top of the conversion zone, for the conversion of an organic reactant, and subsequently dehydrating catalyst with dry gas and returning it to the conversion zone.

H. Z. Martin, assr to Standard Oil Development Co. U.S.P. 2,493,494, 3.1.50. The improvement in heat recovery in a fluidized catalyst regeneration which comprises injecting coarser catalyst into a gas stream containing entrained catalyst powder prior to passing through heat exchanger to prevent accumulation of powder on the surface of the heat exchanger.

E. C. Hughes and S. M. Darling, assrs to S.O. Co. Ohio. U.S.P. 2,493,761, 10.1.50. Cracking catalyst and cracking process comprising cracking the hydrocarbon at suitable conditions of temperature and pressure with silica-free catalyst comprising alumina and 1–20% by weight of beryllium fluoride.

W. A. Pardee and G. E. Elliott, assrs to Gulf Research and Development Co. U.S.P. 2,493,896, 10.1.50. Preparation of silica–alumina catalyst by depositing on activated alumina an organic compound capable of yielding silica.

E. V. Bergstrom, assr to Socony–Vacuum Oil Co. Inc. U.S.P. 2,493,219, 3.1.50. A continuous cyclic process and apparatus for the catalytic conversion of hydrocarbons, using an adsorbent catalyst of different sizes. C. F. S.

Polymerization.

756. Role of peroxides in polymerization. L. Williamson. *J. Oil Col. Chem. Assoc.*, 1949, **32**, 579.—It was accepted that peroxides of drying oils were cyclic in structure, but recent work suggests that if such a peroxide is produced in fatty oil systems it is unstable and undergoes a rearrangement to a more stable form. These peroxidic compounds can be determined by reaction with potassium iodide, and can be shown to be present in increasing quantities, reaching a max in the drying oil film before gelation. Peroxides can be of two types, either mono- or di-substituted derivatives of hydrogen peroxide.

The individual steps in a vinyl polymerization reaction are essentially initiation, propagation, and termination. Each step is discussed.

There are two classes of drying oils: (*a*) the thermally polymerized oils, such as stand oil; (*b*) blown oils and drying oil films. Some of the fundamental properties of these two classes are described. Autoxidation of the methyl esters of the drying-oil fatty acids and mechanisms of bond formation are considered.

Thermal decomposition of peroxide molecules and effect of catalysts, temp, and the oxygen partial pressure on the properties of polymers are discussed. D. K.

757. Patents. W. A. Schulze and W. W. Crouch, assrs to Phillips Petroleum Co. U.S.P. 2,493,268, 3.1.50. An improvement in the production of synthetic rubber by emulsion copolymerization of butadiene and styrene using tertiary hexadecyl mercaptans as the sole modifying agents.

J. D. Hagy, assr. to Stanolind Oil and Gas Co. U.S.P. 2,493,454, 3.1.50. A process for producing normally liquid hydrocarbons from methane. C. F. S.

Alkylation.

758. Patent. D. E. Bergen, assr to Phillips Petroleum Co. U.S.P. 2,493,384, 3.1.50. The treatment by alkylation of hydrocarbons with hydrofluoric acid catalyst.

C. F. S.

Isomerization.

759. Patent. S. F. Perry, assr to Standard Oil Development Co. U.S.P. 2,493,499, 3.1.50. A process of isomerizing a light naphtha fraction containing olefins and aromatics with $AlCl_3$, alumina, and a hydrogen halide promoter, and pretreating the hydrocarbons to be isomerized. C. F. S.

Chemical and Physical Refining.

760. Operating problems relating to gas treating. J. S. Connors and A. J. Miller. *Oil Gas J.*, 2.2.50, **48** (39), 57.—Batch-type treatment and regenerative processes for removal of hydrogen sulphide from natural gas are discussed.

Caustic-soda and lime-slurry processes, examples of batch-type treatments are not normally used; the modified iron-oxide method being favoured. Wood shavings impregnated with iron oxides are placed on trays inside a pressure vessel, and gas is passed downward through the beds.

The spent beds are regenerated by air oxidn, precautions being taken to keep mass damp.

Regenerative processes include the soda-ash, phenolate, tripotassium phosphate, and amine methods.

Operating problems met with in the amine process are discussed, with reference to actual case histories.

Flow diagrams of an iron oxide soda ash, two-stage phenolate, phosphate, and amine gas treaters are given, and two tables show data on the amine gas treaters.

G. A. C.

761. Cycle washing of percolation filters. E. J. Reeves and R. E. Turkleson. *Refiner*, Mar. 1949, **28** (3), 135–7.—The factors which control the volume of naphtha required for washing filters to a predetermined oil content are listed as follows: (1) solvent characteristics; (2) adsorbent properties; (3) temperature of the clay bed; (4) temp of the naphtha; (5) properties of the oil adsorbed by the clay; (6) method of applying naphtha to the adsorbent. The last item was studied with a view to reducing operating costs. Experimental results show that with cyclic washing of the filters, the volume of fresh naphtha may be cut by 75% as compared with the usual procedure employing fresh naphtha for each washing contact. W. E. M.

Special Processes.

762. Ethyl completes expansion programme. Anon. *Chem. Ind.*, Dec. 1949, **65** (6), 890.—The extensions to the Ethyl Corporation plant at Baton Rouge have now been completed at the expense of $40 million. New units allow for increased salt handling to meet larger sodium demands, and for enlarged ethyl chloride and ethylene dichloride capacity. A sixth T.E.L. plant has been added to the existing facilities so that production should be expanded by some 40%. O. M.

763. Underground dam. Anon. *Refiner*, Mar. 1949, **28** (3), 114.—The use of "Shellperm" marketed by the Shell Oil Co. is described. An asphalt-in-water emulsion is pumped at low pressure through a metal pipe driven into the ground, to form a barrier impermeable to water. In this way seepage of water from reservoirs may be prevented. W. E. M.

764. Dry ice manufactured from CO_2 extracted from natural gas. C. D. Gard. *Refiner*, Feb. 1949, **28** (2), 117–22.—A plant is described which removes CO_2 from natural gas in order to meet the requirements of the gas consumers. The CO_2 is converted into dry ice. W. E. M.

765. Underground coal gasification project developing. Anon. *Refiner*, Apr. 1949, **28** (4), 150–1.—Progress in the coal-gasification experiments near Gorgas, Ala., is described. A plant lay-out diagram is shown, together with a schematic diagram of

the process. Preliminary experiments showed that the coal could be kept burning, gasification was complete, and that the roof rock becomes plastic and settles down without cutting off the air or gas. Further information is required on the following points: (1) quantities of coal that can be gasified and the shape and extent of the burned-out area; (2) whether fixed outlets for product gas are practicable (various designs of inlets, outlets, and seals will be tested); (3) operating characteristics under varying conditions; (4) quality and quantity of gas and related products; (5) siting of plants. W. E. M.

766. Catalytic desulphurization of crude oil. S. M. Hale, M. C. Simmons, and F. P. Whisenhunt. *Industr. Engng Chem.*, 1949, **41** (12), 2702–8. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem. 115th meeting Amer. Chem. Soc., San Francisco.*)—The composition and properties of crude oil have been shown experimentally to be greatly improved by cat desulphurization. This treatment removes the most active types of S compounds, thus reducing corrosion problems in the subsequent refining of the oil. The properties of the distillates are improved. Gasoline would have an increased A.S.T.M. motor method clear octane No. and increased lead susceptibility. Volumes of gasoline and gas oil would be increased at expense of residue, thus reducing bottoms. Experiments using H_2 at 225 p.s.i.g. with bauxite, Co–Mo–bauxite and Zn–Mo–bauxite cats showed that better desulphurization would be obtained in this way and that prepared cats gave better results. R. G. T.

767. Desulphurization—hydrogenation of high-sulphur catalytically cracked cycle stock. A. Voorhies, Jr., and W. M. Smith. *Industr. Engng Chem.*, 1949, **41** (12), 2708–10. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem. 115th meeting Amer. Chem. Soc., San Francisco.*)—Simple hydrogenation of a high-S cat-cracked cycle stock at 750 p.s.i. improves the quality of the material converting condensed-ring to H-single-ring aromatics and removing S until the product is as desirable a cracking stock as the virgin gas oil. Cat activity is maintained in the hydrogenation step, product yield is 100%, little change in boiling range occurs and sulphur is removed from a material which otherwise resists desulphurization. Sulphur reduction prior to original cracking of a high-S virgin gas oil or recracking of a high-S cycle stock derived therefrom is shown to be necessary in order to allow production of a gasoline which meets established S specifications without further treating. R. G. T.

768. Sulphur from sour refinery gases. Anon. *Petrol. Process.*, 1949, **4**, 891–2.—A process is described for the extraction of H_2S from sour refinery gases. The H_2S is absorbed in diethanolamine (D.E.A.) at the individual refineries, and the H_2S-rich D.E.A. solution returned to a central chemical plant. At the plant it is steam-stripped and the regenerated D.E.A. solution pumped back to the refineries for re-use. The H_2S is converted to sulphur by a modified Claus process, in which part of the H_2S burns to SO_2, which then reacts with the remainder of the H_2S to yield sulphur of 99·8% purity. W. E. M.

769. Ethylene glycol by air oxidation of ethylene. P. W. Sherwood. *Refiner*, Mar. 1949, **28** (3), 129–34.—The direct air oxidn of ethylene is a process competitive with the usual method *via* ethylene chlorohydrin. The main advantage of the oxidn method is the non-reliance on chlorine. Ethylene is premixed with a large excess of air and then passed through special oil-cooled reactors, where the following alternative reaction take place: (1) $2CH_2=CH_2 + O_2 \longrightarrow 2CH_2-CH_2$ (with O bridging); (2) $CH_2=CH_2 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$. Usual yields are 50–55%, but the development of new "anti-catalysts" promises higher efficiency. A special problem arises in the removal of the high heat of reaction particularly associated with reaction (2), which leads to inefficient conversion. The effects of several process variables are fully discussed. The economics of the process are discussed in relation to the older chlorine method. W. E. M.

770. Hydroforming and thermal reforming operations on sweet and sour heavy straight-run naphthas. N. H. McLaurin, C. H. McIntosh, and D. S. Kaufman. *Refiner*, Apr. 1949, **28** (4), 171–5.—Hydroforming (I) and thermal reforming (II) are compared as

competing methods for increasing the octane ratings of naphthas. Experiments are described with two naphthas—one sweet (0·008% S) and the other sour (0·421% S)—comparing the economics of methods I and II. Experimental results include graphs of free-naphtha yields *v.* dry-gas yields, butane yields *v.* dry-gas yields, polymer yields *v.* dry-gas yields, octane ratings *v.* naphtha yields, sulphur contents of naphtha *v.* naphtha yields, and cost indices *v.* octane ratings of product. It is concluded that : (1) I yields higher octane ratings than II. (2) The relative economics of the two processes were the same for both sweet and sour stocks. (3) II was more economical at low O.N.s, and I more economical at high O.N.s. (4) Sour stocks give better yield–octane relationships than sweet stocks. W. E. M.

771. Researches on carbides formed on iron catalysts during hydrogenation of CO. (Reaction mechanism of the Fischer–Tropsch synthesis. Pt. III.) H. Kölbel and R. Langheim. *Erdöl u. Kohle*, 1949, **2**, 554–60.—Formation and influence of the iron carbide component of the Fe cat was studied. By treatment of pure paramagnetic γ-Fe_2O_3 with CO at 265° C a carbide of composition Fe_2C was prepared. Stability of this, which affected hydrogenation rate of carbide–carbon, depended on the starting material and method of preparation. Influence of alkali and of Cu on these reactions was also investigated. It is concluded that the formation of definite carbides and the synthesis reaction leading to the production of hydrocarbons proceed in parallel. Alkali catalyses both reactions directly, Cu indirectly by accelerating reduction of Fe_3O_4 (cf. Abstract 1567/1949). A. C.

772. Field stress relief of vessels by radiant electric heating. M. Ludwig. *Refiner*, Feb. 1949, **28** (2), 109–111.—A method is presented for the stress relief of heavy-walled pressure vessels during welding operations. The vessel is internally heated by an electric element consisting of ordinary furnace tubing taking power from low-voltage welding machines. W. E. M.

773. Petroleum waxes extend speciality uses. F. W. Padgett and J. W. Padgett. *Chem. Ind.*, Dec. 1949, **65** (5), 905.—Petroleum waxes produced during the manufacture of lubricating oils can be classified as follows : (1) paraffin waxes consisting mainly of normal paraffin hydrocarbons ; (2) petrolatum ; (3) microcrystalline waxes in which the *iso*paraffins predominate.

Petrolatum, because of its high oil content, is largely limited to cosmetic and pharmaceutical applications. Paraffin waxes have lower melting points than the microcrystalline variety and have the property of forming larger crystals. They can be prepared by the sweating process or by solvent methods such as those involving methyl ethyl ketone, whereas microcrystalline waxes, from which it is more difficult to remove oil, must be manufactured by solvent de-oiling. Acid treatment and clay refining can also be used for many types of petroleum wax. The property of occluding oil shown by microcrystalline wax is important in applications where tensile strength and ductility are concerned. Thus mixtures of paraffin waxes and microcrystalline waxes are widely used for packaging when it is essential that no sweating of oil will occur.

The following tests are carried out in routine examination of waxes : melting point hardness, oil content, tensile test and modulus of rupture, and blocking.

A useful list of the properties of waxes commercially available in America is included at the end of this article. O. M.

774. The metallic soaps. R. G. Bossert. *Chemical Education*, Jan. 1950, **27** (1), 10.—Metallic soaps differ from ordinary soaps not only in water solubility, but also in their increased solubility in non-polar (organic) solvents. The metals and acids most commonly used in production of metallic soaps are given, together with the different classes of metallic soaps produced by the various combinations. The two chief methods of preparation are described, and a comprehensive list of industrial applications is given. A. S.

775. Patents. S. A. Ballard, H. de Finch, E. Cerrito, and E. A. Peterson, assrs to Shell Development Co. U.S.P. 2,492,956, 3.1.50. A method for the preparation of unsaturated hydrocarbons from unsaturated ketones by interaction of a non-tertiary

alcohol and a non-aromatic ketone. Catalyst is an adsorptive alumina comprising alumina α-monohydrate, γ-alumina, and an oxide of cobalt and chromium.

A. V. Grosse and J. C. Snyder, assrs to Houdry Process Corporation. U.S.P. 2,492,985, 3.1.50. An improvement in the formation of oxygenated organic compounds by the oxidation of hydrocarbons in the presence of liquid catalytic films.

A. V. Grosse and J. C. Snyder, assrs to Houdry Process Corporation. U.S.P. 2,492,983, 3.1.50. The production of methanol by reacting sulphur trioxide and methane under reaction conditions and temperatures in the range 100–450° C and at least atmospheric pressure.

F. P. Baldwin, assr to Standard Oil Development Co. U.S.P. 2,493,518, 3.1.50. Method of reclaiming vulcanized polymers by treatment with metalloid hydrides.

H. G. Schneider, C. F. Van Gilder, and T. J. Peters, assrs to Standard Oil Development Co. U.S.P. 2,493,781, 10.1.50. A method of isolating and purifying a crystalline alkylated phenol from an acidic crude mixture of alkylated phenol, by washing with hot water and agitating with aqueous alcohol solution. C. F. S.

Metering and Control.

776. Automatic recorder for catalyst loss on cracking units. J. H. Ramser and J. W. Hickey. *Petrol. Process.*, 1949, **4**, 776–8.—An instrument is described for the automatic recording of catalyst loss in the flue gas of fluid-catalytic-cracking plants. An optical device measures the catalyst concn, and a flow meter measures the rate of flue gas. Both are coupled to give readings in terms of instantaneous loss of catalyst per unit time, as well as accumulated total loss. W. E. M.

777. Practical fractionator instrumentation for natural gasoline plant. N. K. Rector. *Petrol. Process.*, 1949, **4**, 525–9.—The problem of automatic control for fractionating columns taking a substantially pure hydrocarbon as overhead product is discussed. A typical control lay-out, suitable for a depropanizer, is described. W. E. M.

778. The mass spectrometer—a tool for the petroleum processor. J. F. Kinder and R. Wertzler. *Petrol. Process.*, 1949, **4**, 515–18.—The application of mass-spectrometry to refinery control is discussed. Successful routine analyses have been made of the following streams: hydrocarbons up to C_7, miscellaneous aromatics, flue gas, sulphur compounds. Average time for a single analysis is 1½ hr.

Methods of handling samples, instrument maintenance, and methods of calculation are described. W. E. M.

779. The measurement of lustre of petrolatums and waxes. A. Kinsel and J. Phillips. *Refiner*, Apr. 1949, **28** (4), 147–9.—An apparatus is described for the measurement of lustre of petrolatums and waxes by a standard method. The principle of operation is the measurement of percentage reflected light from a thin layer of the wax on a glass slide. It is shown that: (1) lustre is independent of colour, and viscosity at 210° F; (2) softer samples tend to have higher lustre indices; (3) samples with low melting points tend to have high lustre indices; (4) petroleum waxes, both micro- and macro-crystalline, have approx the same index. W. E. M.

780. The "Probolog"—for inspecting non-magnetic tubing. G. A. Nelson. *Petrol. Process.*, 1949, **4**, 1112–15.—An instrument is described for the automatic inspection of tube bundles *in situ*. Irregularities in the tube are recorded on a moving tape. W. E. M.

781. The calculation of rotameters. W. B. Howard. *Refiner*, Apr. 1949, **28** (4), 131–4.—New design equations are presented for the construction and modification of commercial rotameters. W. E. M.

Safety Precautions.

782. The use of foam fire protection for solvent process buildings. C. L. Jones. *Petrol. Process.*, 1949, **4**, 673–5.—A permanent installation of foam equipment is described for the protection of processes involving benzene, gasoline, and furfural at pressures of approx 100 p.s.i. and temp around 285° F. The foam apparatus was chosen after testing several alternative extinguishing mediums—water fog at 700 p.s.i., chemical dry powder, water, carbon tetrachloride, inert gas, and various foams. W. E. M.

783. Causes and cures for explosions in compressed air systems. Anon. *Petrol. Process.*, 1949, **4**, 1101–2.—Evidence is presented which suggests that explosions in compressed-air systems (though rare) may be due to the formation of a " carbon–oxygen complex " on carbon deposits in the hot compressor discharge line. Analyses are given of three samples of carbon deposit, taken from compressed-air systems. Each is shown to contain considerable quantities of oxygen. When heated in air, the samples showed evidence of an exothermic reaction and of oxygen consumption. It is suggested that special lubricants should be developed for air-compressors and temp shut-off mechanisms incorporated in discharge lines. W. E. M.

784. Dermatitis from cutting oils. Anon. *Mech. World*, 10.2.50, **122** (3291), 148.—Insoluble lubricating oils are more frequently producers of dermatitis than coolant soluble oils. When using an insoluble cutting oil the actual exposure to oil is greater than when using the coolant form which contains only a small percentage of raw oil. All oils may plug pores of the skin and form oil pimples, but petroleum oils which form basis of insoluble type have additional property of defatting the skin. Dermatitis can be prevented by avoiding contact with the oil, but in the prevention of usual type of dermatitis from cutting oils, personal hygiene is the primary factor. In every establishment employing cutting oils good washing facilities should be provided. If protective ointments are used they should be of a type which fill the pores of the skin with a non-irritating vegetable or animal fat. There is also protective clothing on the market which will provide a valuable barrier against dermatitis. A. S.

785. Trichlorethylene. Anon. *Industrial Bulletin*, Jan. 1950, **18** (180), 4.—The paper describes the known effects of the solvent and of cold vapour on the skin and eyes. It is claimed that there is no support for the statement that cold trichloroethylene vapour/air mixtures can cause first- or second-degree burns of the skin or corneal abrasions of the eye. High vapour concn in air may be expected to cause smarting of the eye, but this passes off without any lasting damage. Simple first-aid treatment is indicated. Trichlorethylene vapour has a narcotic effect, and will cause drowsiness if inhaled. A list of precautions is given to avoid this, and safety rules are given for cleaning out and entering degreasing plants. A. S.

Products.

Chemistry and Physics.

786. The dynamics of gas flow. W. H. Rodebush. *Chemical Education*, Jan. 1950, **27** (1) 39.—The paper discusses some of the more interesting phases of the subject of gas dynamics. Included in these are brief references to supersonic flow, mechanical shock waves and the Hugoniot equation, and detonations. A. S.

787. Thermochemistry for the petrochemical industry. K. A. Kobe and E. G. Long. *Refiner*, 1949, **28**.—In a series of articles, recommended thermodynamic data are presented for pure hydrocarbons. The references to the individual papers and contents are as follows :

Part I—Introduction. Jan. (1), 83 : The method of selection of the data and their usefulness are discussed.

Part II—Paraffinic hydrocarbons, C_1–C_6. Feb. (2), 113–16 : Free energies of formation, heats of formation, heats of combustion, heat capacities, and enthalpies.

Part III—Monolefinic hydrocarbons, C_2–C_4. Mar. (3), 125–8: Free energies of formation, heats of formation, heats of combustion, heat capacities, enthalpies of ethylene, propylene, 1-butene, *iso*butene, cis-2-butene, trans-2-butene.

Part IV—Cycloparaffinic hydrocarbons. May (5), 161–3: Heat capacities and enthalpies of *cyclo*pentane, methyl *cyclo*pentane, *cyclo*hexane, and methyl *cyclo*hexane.

Part V—Aromatic hydrocarbons. July (7), 145–8: Free energies of formation, heats of formation, heats of combustion, heat capacities, and enthalpies of benzene, toluene, ethylbenzene, styrene, and cumene. W. E. M.

788. Effects of pressure on enthalpy and entropy. W. C. Edminster. *Refiner*, Feb. 1949, **28** (2), 137–47.—Correlations are presented for the isothermal effects of pressure on entropy and enthalpy for single- and multi-component hydrocarbon systems. Comparisons are made with other correlations and with experimental values. Data calc by this correlation are presented for the following systems: methane, ethylene, ethane, propane, *iso*butane, *n*-butane, *n*-pentane, *n*-heptane, *iso*-octane, benzene, methane–ethane, methane–propane, methane–*n*-butane, and methane–*n*-pentane. W. E. M.

789. Enthalpy–entropy plots for pure hydrocarbons. W. C. Edminster. *Refiner*, Mar. 1949, **28** (3), 139–50.—A rapid method of constructing approx Mollier diagrams for pure hydrocarbons is described and illustrated. The method is compared with more rigorous methods. W. E. M.

790. Entropy charts for hydrocarbon mixtures. W. C. Edminster. *Refiner*, Apr. 1949, **28** (4), 157–66.—The construction of Mollier diagrams for hydrocarbon mixtures is described. The effects of temp on entropy and enthalpy are obtained at the ideal gas state, and the effects of pressure are calc by generalized correlations. The method involves the construction of a vapour–liq equilibrium diagram for the mixture. Diagrams are given for the following mixtures: ethane–butane, "plant propane," propane–propylene, and propane–butane. W. E. M.

791. Influence of the nature and extent of walls on inflammation and combustion reactions in the gaseous phase. W. P. Jorissen. *Rev. Inst. franç. Pétrole*, 1949, **4**, 326–8.—Study of the slow oxidn of CH_4 by O_2 in tubes whose walls were covered with halides of group I elements showed that the temp at which CO_2 became perceptible when different salt coatings were used increased in the order Li, Na, K, Rb and F, Cl, Br, I. The amount of anhydrous powdered salts (of same particle size) required to suppress inflammation in a given mixture of CH_4 and air increases from Na to K and F to I in the alkali metal halide series. Figures are also given for other salts. Fifteen references. E. B.

792. Water-vapour content of essentially nitrogen-free natural gas. E. L. McCarthy, W. L. Boyd, and L. S. Reid. *Oil Gas J.*, 5.1.50, **48** (35), 59.—A correlation of data from several sources is presented in graphical form and provides a quick method for determining the water-vapour content of natural gas composed chiefly of methane with other paraffin hydrocarbons and essentially free of nitrogen or other inert gases for various temperature–pressure conditions. G. A. C.

793. Ignition of a hot gas bubble. P. Gray. *Rev. Inst. franç. Pétrole*, 1949, **4**, 355–7.—Pressures of >100 atm have been recorded in gas bubbles within a liq, such as nitroglycerine, subject to sudden impact. The test apparatus employed utilized the piezoelectric effect of quartz and a cathode-ray oscilloscope. Temp of the order of 1000° C are calc to be reached by the gas. Efficacy of gases as ignition initiators is dependent upon the sp. ht. ratio of the gas. Chem nature of the gas also influences the sensitivity of the explosive; at low pressures in the absence of other gases nitroglycerine or methyl nitrate vapours are more effective than $(Et)_2O$, C_5H_{12}, or CCl_4. At all pressures O_2 and air are more effective than N_2. Experimental evidence is considered to support the theory that ignition takes place by inflammation of the explosive vapour within the hot gas bubble. E. B.

794. Mass spectra of C_5H_8 isomers. F. L. Mohler, E. G. Bloom, L. Williamson, C. E. Wise, and E. J. Wells. *Bur. Stand. J. Res., Wash.*, Dec. 1949, **43** (6), 533.—Mass spectra of ten C_5H_8 isomers have been obtained, and are described. They were

obtained on a 180° consolidated-mass spectrometer using automatic electric-current control and automatic temp control of the ionization chamber at 245° C. The samples examined consisted of spiropentane, methylene*cyclo*butane, *cyclo*pentane, six dienes, and 1-pentyne. The ratio of total ionization to that of *n*-butane covers a small range of values from 0·96 to 1·09, and the same range of values is found in other C_5 hydrocarbons. The doubly charged ion spectrum is very prominent in some pentadienes, with $C_5H_2^{++}$ the largest peak. A. S.

795. New values of equilibrium constants occurring in combustion products of hydrocarbons. N. Manson and H. Guénoche. *Rev. Inst. franç. Pétrole*, 1950, **5**, 17–24.—Equilibrium const have been calc, by interpolation and extrapolation from values given in U.S. Bureau Standards circular C 461, to give values at intervals of 100° in range 1000–4000° K for the following seven equilibrium states: $\frac{1}{2}H_2 = H$; $\frac{1}{2}O_2 = O$; $\frac{1}{2}N_2 = N$; $\frac{1}{2}N_2 + \frac{1}{2}O_2 = NO$; $CO_2 = CO + \frac{1}{2}O_2$; $H_2O = H_2 + \frac{1}{2}O_2$; $H_2O = OH + \frac{1}{2}H_2$, for each of which the K_P and $K_P^{\frac{1}{2}}$ values are quoted. Equilibrium const are also given for $CO_2 + H_2 = CO + H_2O$ for 300–2500° K in steps of 100°. The best values of the published data are critically discussed, and the probable accuracies for the above eight equilibria tabulated. V. B.

796. Oxidation and pyrolysis. Induction of pyrolysis of organic vapours by very small amounts of oxygen. Case of acetaldehyde. M. Letort and M. Niclause. *Rev. Inst. franç. Pétrole*, 1949, **4**, 319–24.—Previous work on the effect of small amounts of O_2 on the pyrolysis of org vapours is briefly reviewed. (Fifteen references.) Experimental technique and apparatus for studying the O_2-induced pyrolysis of CH_3CHO is described. Temp range covered was 147–404° C with initial pressure CH_3CHO and O_2 237 mm and 0·10 mm (0·04% vol) respectively. Decomp, one vol CH_3CHO giving rise to 2 vol products (50% CO), was observed by measuring increase of pressure with time. Reaction rate increased to const val after time *t*, which varied with temp from several hr at *ca* 150° C to 30 sec (min) at 315° C. The No. of mols CH_3CHO decomp per mol O_2 increases to a max at 200° C, falls to a min at 315° C and rises again up to 404° C. The vessel walls inhibit the reaction rate, the effect decreasing with temp. When O_2 concn falls the No. of mols CH_3CHO decomp per mol O_2 increases, an effect becoming more marked with rising temp. Effect of walls and of sensitizer concn suggest two chain-breaking processes, one at the walls and the other in the gas phase. E. B.

797. Role of aldehydes in hydrocarbon oxidation. R. G. W. Norrish. *Rev. Inst. franç. Pétrole*, 1949, **4**, 288–300.—Two consecutive reactions occur in the oxidn of CH_4, $CH_4 + O_2 \longrightarrow HCHO + H_2O \longrightarrow CO + 2H_2O$, except at high temp when CH_3OH is an intermediate. Stable peroxides have not been detected. Kinetics of oxidn of CH_4 and HCHO are discussed, and equations given representing the mechanism of the reactions, involving degenerate chain processes dependent on free radicals, OH, HO_2 and H. Oxidn of C_2H_4 is also discussed, and the role of HCHO considered here and in the oxidn of higher hydrocarbons. E. B.

798. Slow oxidation of di-*iso*propyl ether in the temperature range 360–460° C. G. H. N. Chamberlain and A. D. Walsh. *Rev. Inst. franç. Pétrole*, 1949, **4**, 301–13.—Oxidn of ethers shows characteristics of hydrocarbon oxidn. In temp range considered high temp oxidn is predominant. Max reaction rate $\propto P^4_{\text{initial}}$ at 360° C and $\propto P^3_{\text{initial}}$ at 420° C. Dependence of max reaction rate on the partial pressures is given by max rate $= K \cdot P^2_{\text{ether}} \cdot P_{O_2} \cdot P_{\text{total}}$; effect of P_{total} diminishes at 420° C. Equation is similar to that for the slow oxidn of CH_4. Chain-branching in oxidn of the ether is of the delayed type associated with HCHO in CH_4 oxidn. The oxidn is catalysed by HCHO and CH_3CHO, both present as oxidn products, CH_3CHO being more effective. $\tau P^4_{\text{total}} = \text{const}$ and $\tau \propto \frac{1}{P^2_{\text{ether}}} \cdot \frac{1}{P_{O_2}} \cdot \frac{1}{P_{\text{total}}} \cdot e^{\frac{21000}{RT}}$ give relationship between induction period, τ, and partial pressures and temp. Theory of slow oxidn of CH_4 at 480° C is considered, and a similar mechanism advanced for the oxidn of di*iso*propyl ether at 360° C. Effect of adding NO_2 and org peroxides to the ether oxidn system is discussed, and the reaction $HO^*_2 + NO_2 \longrightarrow HO_2 + NO + O$ considered to take place when NO_2 is present during the oxidn of H_2, hydrocarbons, and ether with O_2. T.E.L. and PbO have a pronounced inhibiting effect on the oxidn of di-*iso*propyl ether at 360° C. E. B.

799. Oxidation of hydrocarbons catalysed by hydrogen bromide. (Summary.) F. F. Rust and W. E. Vaughan. *Industr. Engng Chem.*, 1949, **41** (11), 2595–7.—Hydrogen bromide modifies gas-phase oxidation of lower hydrocarbons. Ethane is converted mainly to acetic acid, straight-chain paraffins mainly to ketones, and branched-chain compounds chiefly to stable peroxides. Product character is principally determined by most reactive C–H linkage in the mol. Reactivity of these linkages increases markedly in the order—primary, secondary, tertiary. Introduction of oxygen under these conditions is accompanied by a low degree of C–C bond scission, operating temps are low, and conversions and yields high. R. G. T.

800. Oxidation of hydrocarbons catalysed by hydrogen bromide—oxidation of branched-chain compounds. E. R. Bell, F. H. Dickey, J. H. Raley, F. F. Rust, and W. E. Vaughan. *Industr. Engng Chem.*, 1949, **41** (11), 2597–604.—Oxidation of *iso*butane and related branched-chain compounds gives high yields of organic peroxides. The mechanism corresponds to a free-radical-chain reaction in which the cat affects initiation and propagation. Apparatus and experimental procedure are described. The effect of silica-gel coating is described. R. G. T.

801. Oxidation of hydrocarbons catalysed by hydrogen bromide—oxidation of ethane and related compounds. E. R. Bell, G. E. Irish, J. H. Raley, F. F. Rust, and W. E. Vaughan. *Industr. Engng Chem.*, 1949, **41** (11), 2609–12.—Oxidation of ethane in presence of hydrogen bromide results in high yields of acetic acid. A free-radical mechanism involving transitory peroxidic compounds is postulated. The same cat process can be used to convert ethyl bromide and ethylene to acetic and bromoacetic acids. R. G. T.

802. Oxidation of hydrocarbons catalysed by hydrogen bromide—oxidation of aromatic compounds. B. Barnett, E. R. Bell, F. H. Dickey, F. F. Rust, and W. E. Vaughan. *Industr. Engng Chem.*, 1949, **41**, (11), 2612–16.—Hydrogen bromide catalysis of aromatic hydrocarbon oxidation gives acids or ketones when primary or secondary H atoms on the side chain are attacked. Modification of these reactions by scission of postulated peroxide intermediates yields phenol and aliphatic ketones or acids. The scission reaction is dominant when tertiary H atoms are attacked, *e.g.*, in cumene. HBr also catalyses oxidation of alkyl benzenes in liquid phase. R. G. T.

803. Oxidation of hydrocarbons catalysed by hydrogen bromide—oxidation of straight-chain compounds. P. J. Nawrocki, J. H. Raley, F. F. Rust, and W. E. Vaughan. *Industr. Engng Chem.*, 1949, **41** (11), 2604–9.—Ketones in high yield are produced by hydrogen-bromide-catalysed oxidation of propane, butane, and related compounds containing secondary C atoms. A free-radical-chain mechanism involving intermediate hydroperoxide formation is postulated. The reaction is profoundly affected by certain organic compounds which act as chain-branching agents, *e.g.*, *iso*propyl chloride, or chain initiators, *e.g.*, di-*tert.*-butyl peroxide. R. G. T.

804. Compressibility and critical constants of propylene vapour. H. Marchman, H. W. Pringle, Jr., and R. L. Motard. *Industr. Engng Chem.*, 1949, **41** (11), 2658–60.—The following characteristics of propylene are presented—compressibilities from 10 to 215 atm and from 30° to 250° C, critical properties, vapour pressure, and saturated vapour volumes. Constants for the Benedict–Webb–Rubin equation of state are reported and correlated densities of up to 9 mols/litre with overall deviation of 0·2%. R. G. T.

805. Synthesis of methyl-1 : 2-benzanthracenes. W. S. Newman and R. Gaertner. *J. Amer. chem. Soc.*, 1950, **72** (1), 264–73.—In order to make available sufficient material for carcinogenic studies new synthesis for 3-, 6-, 7-, 8-, 2′-, and 3′-methyl-1 : 2-benzanthracenes have been developed, and previously reported synthesis of the 4-, 5-, and 9-isomers have been improved. Samples of 1 : 2-benzanthracene, 10-methyl-, and 9 : 10-dimethyl-1 : 2-benzanthracene have also been prepared by standard methods. W. H. A.

806. Three new octenes. F. C. Whitmore, H. E. Whitmore, and W. C. Cook. *J. Amer. chem. Soc.*, 1950, **72** (1), 51–3.—The synthesis of 5 : 5-dimethyl-2-hexene, 2 : 4-di-

methyl-3-hexene, and 3-ethyl-4-methyl-1-pentene is described, and their principal physical properties determined. The two dimethyl hexenes were prepared by dehydration of the corresponding alcohols, which were synthesized by the Grignard reaction and the 3-ethyl-4-methyl-1-pentene by acetylation of 2-methyl-2-pentene; hydrogenation of the resulting ketone followed by dehydration of the secondary alcohol formed. W. H. A.

807. Heats of adsorption and molecular configuration of the pentanes on carbon black. R. A. Beebe, G. L. Kington, M. H. Rolley, and W. R. Smith. *J. Amer. chem. Soc.*, 1950, **72** (1), 40–3.—The isotherms and calorimetric heats of adsorption at 0° of *n*-butane, *n*-pentane, neopentane (2 : 2-dimethylpropane), and *cyclo*pentane on carbon black have been determined. It was found that the *n*-paraffins have heat values in which the $-CH_2$ and $-CH_3$ groups contribute approximately 3 k.cal/mol, but that these groups contribute less than 3 k.cal in the case of *neo*pentane and *cyclo*pentane, and it is suggested the differences in binding energies indicated by these values may be attributed to differences in geometric fit of the molecules on the carbon-black surface. W. H. A.

808. Synthesis of pyrene. W. Baker, F. J. W. McOmie, and J. M. Norman. *Chem. & Ind.*, 1950, (4), 77.—*m*-Xylylene dibromide was treated with sodium yielding di-*m*-xylylene; dehydrogenation of this product with palladium–charcoal produced pyrene. Application of this synthesis to the preparation of other polycyclic aromatic hydrocarbons is mentioned. W. H. A.

809. Mechanism of flame propagation in gaseous mixtures and the role of projection of active centres. N. Manson. *Rev. Inst. franç. Pétrole*, 1949, **4**, 338–54.—Previous work is reviewed. (Forty-three references.) Theory developed completes that of shock and combustion waves of Jouguet. It allows the calculation of velocities for stationary flames (in good agreement with experimental values obtained by Gouy's method), and the pressure drop in the front of a uniform moving flame. Certain discrepancies are discussed in the light of overall reaction schemes, accuracy of thermodynamic const, and method of calculating burned-gas composition. E. B.

810. Flame propagation in ethylene–air mixtures. J. W. Linnett and M. F. Hoare. *Rev. Inst. franç. Pétrole*, 1949, **4**, 330–6.—Speed of deflagration of various C_2H_4/air mixtures was measured at ambient temp and atm pressure. Experimental work is described and results discussed. Speed of deflagration was determined from measurement of the burner-cone shadow projected on to a photographic film. It was concluded that flame propagation depended both on the thermal conductivity and on the diffusion of free radicals and atoms. E. B.

811. Vapour pressures and boiling points of sixty API–NBS hydrocarbons. A. F. Forziati, W. R. Norris, and F. D. Rossini. *Bur. Stand. J. Res., Wash.*, Dec. 1949, **43** (6), 555.—Measurements of vapour pressures and boiling points were made over the range 48–780 mm Hg and above about 11° C, on sixty hydrocarbons of the API–NBS series. The paper gives the experimental data, and results of the correlation with the Antoine equation, for seventeen paraffin, fourteen alkyl*cyclo*pentane, eight alkyl*cyclo*hexane, and twenty-one alkylbenzene hydrocarbons. A. S.

812. The relation between heat transmission and flow resistance. J. A. Businger. *Ingenieur*, 27.1.50, **62** (4), Ch. 1.—Some physical aspects of heat transmission and flow resistance are discussed, and in particular the relation between these quantities. Thereby use is made of dimensionless numbers. If in a certain case Nu and f are known as functions of Re, then we are able to calculate the ratio $\frac{Nu}{fRe}$. This ratio has a certain significance with regard to the economics of the use of materials in heat exchangers. This is explained by means of several examples. It is shown that streamlined bodies have a favourable shape with respect to heat transmission.

Finally, we consider the heat transfer of the inflow edge of a flat surface. This consideration holds more or less for sharp edges in general. R. R.

813. Calculation of the absolute value of the viscosity of a liquid. G. M. Panchenkov. *Doklad. Akad. Nauk S.S.S.R.*, 1948, **63**, 701–3.—The following expression is derived, and is a correction of one earlier suggested by the same author (*Doklad. Akad. Nauk S.S.S.R.*, 1945, **50**, 329).

$$\eta = \alpha\gamma^2 M^{-5/6}\rho^{4/3}T^{1/2}f_s\epsilon^{\epsilon/RT}(1 - \epsilon^{-\epsilon/RT})^2$$

where $$\alpha = 3\sqrt{6}R(\tfrac{4}{3}\pi)^{2/3}N_0^{1/3}.$$

The symbols have the following meanings : R = universal gas const ; N_0 = Avogadro's No. ; r = molecular radius ; M = mol. wt. ; ρ = density ; T = absolute temp ; ϵ = binding energy of the liq molecules, calc from internal latent heat of evaporation ; f_s = " steric multiplier." This latter can be calc from the decrease in entropy on the formation of a bond, which can be determined from a knowledge of the latent heat of evaporation and the co-ordination No. of the liq. For C_6H_6 and CCl_4 f_s = 0·034 and 0·032 respectively and, using these values in the above expression, the calc result for the visc of these liq is in good agreement with experimental values. V. B.

814. Vapour–liquid equilibria in ideal mixtures. W. C. Edminster. *Refiner*, May 1949, **28** (5), 149–60.—A method is given for the calculation of ideal equilibrium constants from thermodynamic properties. Diagrams include plots of fugacity and equilibrium constants for the lower aliphatic hydrocarbons. W. E. M.

815. Vapour–liquid equilibrium in non-ideal systems. W. C. Edminster. *Refiner*, June 1949, **28** (6), 143–8.—A method is suggested for the separate correlation of vapour and liq fugacities on the basis of calc, or experimentally determined, equilibrium constants. W. E. M.

816. Experimental vapour–liquid equilibrium methods and empirical correlation of data. W. C. Edminster. *Refiner*, Aug. 1949, **28** (8), 128–34.—The methods which have been used for obtaining experimental vapour–liq equilibrium data are reviewed, and sketches of several types of apparatus are given. A nomograph is reproduced from another source giving the equilibrium constants for eighteen light hydrocarbons over a wide range of temp. W. E. M.

817. Some chemical and physical properties of rubber. J. Moore. *Brit. J. appl. Phys.*, Jan. 1950, **1** (1), 6.—The chemical constitution and physical state of natural rubber in its viscous, high-elastic, and crystalline conditions are described. It is shown that these depend on long hydrocarbon chains which are normally coiled and tangled. The large elastic extensions obtainable with rubber are due to the ability of these chains to straighten and recoil. By breaking down the cohesion between the chains by various means, for example, by milling on heavy rollers, rubber can be given some of the characteristics of a thick oil. On the other hand, different treatments, for example, intense cooling in a stretched condition, cause rubber to show crystalline properties.

Elasticity is shown to result from the properties of the molecular chains rather than from the properties of the individual atoms composing them. This principle is exemplified by synthetic elastomers and silicone rubbers, where organic groups are substituted by inorganic atoms or groups. R. V. W.

Analysis and Testing.

818. Organization and functions of an analytical and testing group. R. P. Chapman. *Chem. Ind.*, Nov. 1949, **65** (5), 718.—To illustrate the advantages of semi-centralization, the author explains the functioning of an analytical group laboratory whose duties he lists as follows :—

(1) To furnish analytical and physical testing service to all other groups in the laboratory.

(2) To carry out a research programme aimed at the development of new methods or the improvement of old ones.

(3) To aid other units of the company when requested.

(4) Collaborative work with scientific societies.

This group, which is divided into sections covering the various aspects of its work, although being a separate unit, works in full collaboration with other groups in the laboratory, and is always prepared to undertake work, arising at the suggestion of these other groups, which promises the obtaining of useful information. The author stresses the importance of having an efficient method for the distribution of information in order that the work of the group can be of most use. He also emphasizes the necessity of supplying the max amount of background information in order that the chemist undertaking the practical work may be able to take an intelligent interest in it through the realization of the importance of the problem he is helping to solve. O. M.

819. The application of multiple factor analysis to industrial test data. R. Harper, A. J. Kent, and G. W. Scott-Blair. *Brit. J. appl. Phys.*, Jan. 1950, **1** (1), 23.—The technique known as Multiple Factor Analysis is outlined, and its relevance to the physical problems of industry is discussed.

In particular, the method is applied to data obtained from a set of rheological and electrical tests carried out on some plastic materials Three " factors " are sufficient to account for all the observed relationships between the ten tests.

Three numerical solutions have been worked out, one involving non-orthogonal " factors " presenting the simplest solution for interpretation. All the solutions are linear transformations of each other. R. V. W.

820. Note on the interpretation of multiple factor analysis. A. J. Kent. *Brit. J. appl. Phys.*, Jan. 1950, **1** (1), 28.—An interpretation is given, in physical terms, of the mathematical results presented in an earlier paper (cf. Abstract 819), *Brit. J. appl. Phys.*, Jan. 1950, **1** (1), 23. A multiple-factor analysis showed that each of ten tests measured some combination of three fundamental factors, each factor representing a property or quasi-property of the material tested.

This knowledge is developed by interpreting the vector model in terms of current ideas on high-polymer molecules.

Considerations of the grouping of the vectors of the vector model indicate that the two most important factors may be the freedom of rotation of the carbon–carbon polymer-chain linkages and the polar nature of the plasticizers used. This conception is shown to agree with the whole structure of the vector model. R. V. W.

821. Amperometric titration of mercaptans. N. Strafford, F. R. Cropper, and A. Hamer. *Analyst*, 1950, **75**, 55.—β-Mercaptanaphthalene and mercaptabenzthiazole were examined amperometrically by silver nitrate titration in ammoniacal ethanol solution. The results were lower than those by iodine and alkali titrations. The low amperometric results were suspected to be due to oxidation during the titration. Three tests were carried out from which it is concluded that the main source of oxidizing agent is the dissolved air in silver nitrate solution as normally used in the ammoniacal ethanol. The potentiometric titration in neutral alcohol solution gives a satisfactory result, as the mercaptan is less susceptible to oxidation in a neutral solution. J. T.

822. New gas analysis apparatus. E. Freling and P. Dugleux. *Rev. Inst. franç. Pétrole*, 1950, **5**, 3–8.—A detailed description, with diagram, is given of an apparatus primarily designed for examination of gases during combustion. The apparatus is all glass, with no rubber connexions ; Hg is used to accomplish gas transfer. Mixtures containing H_2O, CO_2, CO, H_2, CH_4, O_2, and N_2 can be examined. Solid reagents are preferred to liq, anhyd Mg perchlorate being used to retain H_2O and ascarite for CO_2. Hopcalite was tested as an absorber for CO, but proved insufficiently selective, since H_2, if present, was also partially oxidized and partially adsorbed. It was, however, discovered that in the presence of Hg hopcalite retains O_2. This determination is the final one in the sequence. CO and H_2 are determined by selective combustion over CuO at 270° C (±5° C), whilst a second combustion over Pt measures hydrocarbons. H_2O and CO can be determined to 0·1%, O_2 to 0·5%, but the latter figure can be greatly improved by taking the mean of successive results. Analyses take about 2 hr. V. B.

823. Equipment for compressibility measurements—data on propane. B. J. Cherney, H. Marchman, and R. York, Jr. *Industr. Engng Chem.*, 1949, **41** (11), 2653–8.—A method and equipment for measurement of pressure–vol–temp characteristics of fluids

from room temp to 300° C and from 10–220 atm is described. V.p. crit properties can be measured in addition to compressibilities. 0·25% accuracy is claimed. Measurements on propane have verified this claim. New data on propane are supplied.
R. G. T.

824. Separation of sulphur compounds by adsorption on silica gel. D. Haresnape, F. A. Fidler, and R. A. Lowry. *Industr. Engng Chem.*, 1949, **41** (12), 2691–7. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem. 115th meeting Amer. Chem. Soc., San Francisco.*)—Synthetic blends of sulphur compounds in petroleum were analysed by filtration through a 175-cm column of SiO_2 gel to enable determination of relative adsorbabilities of the different types of S compounds found in petroleum distillates. Apparatus and experimental procedure are described. The compounds examined were more strongly adsorbed than aromatic hydrocarbons, the order of increasing adsorbability being: aromatic hydrocarbons, thiophenes, alkane thiols, alkane disulphides, aromatic and *cyclo*alkane thiols, alkane sulphides, and cyclic sulphides. Relation between b.p. and mol. wt. and adsorbability is discussed. Caustic-soda washing or sulphuric-acid treatment for separation of certain sulphur compounds in straight-run naphthas are described. Thirteen adsorptograms are supplied.
R. G. T.

825. Extraction of sulphur compounds with hydrogen fluoride. A. P. Lien, D. A. McCaulay, and B. L. Evering. *Industr. Engng Chem.*, 1949, **41** (12), 2698–702. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem. 115th meeting Amer. Chem. Soc., San Francisco.*)—The extraction of organic sulphur compounds with anhydrous liquid HF shows an orderly progression with changes in mol. wt., configuration of substituent group, or type of sulphur compound. Extraction increases in order: mercaptans, disulphides, thio-ethers, but decreases with increasing mol. wt. for a given type. Transition from primary to secondary to tertiary alkyl substituents results in increased extraction; introduction of phenyl group lowers extraction. The orderly arrangement supports the Lewis acid-base concept and the fundamental principles of electronegativity as related to structure. It thus enables prediction of ease of extraction of S compounds which have not been investigated. Certain sulphur compounds undergo intra- and intermolecular reactions in presence of HF. Addition of olefin to difficultly extractable mercaptans yields thio-ethers soluble in HF, and thereby markedly enhances the degree of extraction. The important applications of these facts are discussed.
R. G. T.

826. Distillation properties of crude oils. K. K. Rumpf. *Erdöl u. Kohle*, 1950, **3**, 21–4.—Dist curves of crudes can be depicted as straight lines if the reciprocal of the dist temp (expressed as ° absolute) is plotted against total amount dist, the co-ordinates used for the latter being those of probability distribution. Hence the dist curve of a crude can be obtained from a knowledge of two points (preferably amount dist at 200° and 300° C). Typical curves are given, with explanations. Method permits of distinguishing between natural crudes and other pet mixtures, and enables yields of various cuts to be determined. Representation of the crude dist curve on this basis also gives certain indications regarding the genesis of pet.
V. B.

827. Evaluation of the oxidation-resistance and miscibility of mineral oils by means of the neutralization value. L. Stanisavlievici. *Schweiz Arch. Ang. Wiss. Tech.*, 1950, **16**, 9–21.—Oxidn tests by the Weiss–Salomon procedure were carried out on a No. of transformer (seventeen new, six used) and turbine (four new, two used) oils, mostly of Roumanian origin. Inspections, including Tar No. (VDE) on the new transformer oils, are given. Acidity of the sludge formed was 50–200 mg KOH/g and fairly const despite increase of sludge quantity with test duration. Latter was prolonged up to 480 hr in some cases, both acidity development and sludge formation being plotted against time. In almost every case the acidity development curve is similar in shape to and follows the sludge curve, and thus acidity development in this test can be taken as an indication of oil quality. A max acidity limit of 1·5 after 200 hr (at 115° C with Cu cat) is suggested as suitable spec requirement for new oils; the shape of the acidity/time curve can also yield valuable information. The same acid val can be taken as max permissible in oil in use. The effect of various modifications of the Weiss-Salomon procedure was studied, including elimination and variation of Cu cat, but not change

of temp. Such modifications affect amount of sludge more than acidity development. Tests by the same oxidn method on eighteen oil mixtures indicated that mixing of even widely different oils, both new and used, is permissible, the oxidn characteristics of the mixture (sludge and acidity formation) being (except in one case) better than that of the inferior component. Acidity development can therefore also be used as a test for the miscibility of oils, mixing being permissible if the acidity/time curve lies between those for the mixture components. Four used-oil mixtures were subjected to a two-year field test which confirmed laboratory findings. V. B.

828. Normalbenzin for estimation of hard asphalt in mineral oils. F. Schlosser. *Erdöl u. Kohle*, 1950, **3**, 25–6.—A brief historical review of the origin of Kahlbaum's "normalbenzin," which is now again available. The spec for the material is discussed. Each batch is checked for asphalt-precipitating power against an oil of known asphalt content, the permissible variation being ±0·02%. Despite proposals to substitute synthetic hydrocarbons of known composition for "normalbenzin," the latter is still firmly entrenched as an analytical reagent. V. B.

829. Calculating the performance of motor fuel blends. J. S. Bogen and R. M. Nichols. *Industr. Engng Chem.*, 1949, **41** (11), 2629–35.—A method and substantiating data are given for estimation of performance characteristics of multicomponent motor-fuel blends. Four major components of fuels are included—straight-run, thermally cracked, polymer, and catalytically cracked gasolines from Mid-continent crude. Blends which covered practical commercial concns were made and rated by F-1, F-2, and F-8B (modified Borderline procedure) methods, clear and with 1 and 3 ml T.E.L/gal. Curves are given enabling estimation of performance characteristics. Only typical examples are included, but data are given from which the complete series may be drawn. Future work is to include other crude stocks. R. G. T.

830. Method for measuring the thickness of molecular layers adsorbed by a metal in the course of lubrication. J. J. Trillat and J. Brigonnet. *Rev. Inst. franç. Pétrole*, 1950, **5**, 13–16.—A polar material (*e.g.*, oleic acid) is dissolved in known amount in a non-polar highly refined white oil. The solution is placed in contact with a large No. of carefully cleaned steel balls (1280 of dia 3·175 mm in example given). Measurement of the interfacial tension oil–water before and after such contact enables quantity of polar material adsorbed to be calc, and hence thickness of layer determined. Using a solution of oleic acid 1 : 6000 and contact times of 1 min to 8 hr, thickness of layer varied from 11 to 23 mols. Increase in amount of oleic acid adsorbed decreases with contact time, and layer thickness tends to a max, being (in mols) 11 after 1 min, 17 at 30 min, 21 at 2 hr, 22 at 4 hr, and 23 at 8 hr (at 35° C). V. B.

831. A method and apparatus for determining the ignition characteristics of plastics. N. P. Setchkin. *Bur. Stand. J. Res., Wash.*, Dec. 1949, **43** (6), 591.—A method for the determination of the ignition temperatures of plastics is described. Twenty-seven specimens of plastics with a wide range of physical properties and ignition characteristics were tested in order to determine the validity of the method and the adaptability of the apparatus. The method is suitable for the determination of flash-, as well as self- or autogenous-ignition temperatures. It generally results in lower and more consistently reproducible values of the self-ignition temp than those reported by several other investigators. A. S.

832. The microdetermination of "Naphtha" in solution. H. Barnes. *J. Oil Col. Chem. Assoc.*, 1949, **32**, 610.—The method depends on the colour given by many aromatic hydrocarbons in sulphuric acid solution in the presence of formaldehyde. There are three disadvantages which are apparent because naphtha is not a pure compound, these are : a new calibration curve must be constructed for each batch of solvent; the method is empirical, and determinations and calibrations should be carried out under precisely controlled conditions; there may be preferential leaching of the several components of the naphtha, therefore the extracts may not be strictly comparable with the controls.

Details of reagents, apparatus, and solvents are given.

It is believed that quantities of the order of 5 μg may be determined. The limit is set by the control of conditions, particularly during the distillation process. D. K.

833. Consistency of petrolatum and waxes. A. Kinsel. *Chem. Prod.*, Jan. 1950, **13** (2), 61.—Before the advent of the penetrometer, the consistency of petrolatum was measured by "feel." Even with the A.S.T.M. penetrometer, the much smaller range of consistency for petrolatum than for lubricating greases rendered the use of this instrument in connexion with the former product open to serious error.

The investigation described in this article is based on the use of penetration cones of various angles, but each weighing 150 g to illustrate the variation in results which could be obtained with the normal cone specified by the A.S.T.M. and also to determine which cone would yield a similar result to the A.S.T.M. The use of a single-angle cone when blending various petrolatums to a given penetration is obvious.

A further drawback to the A.S.T.M. technique is the impossibility of using it in conjunction with small samples. A method, based on the use of a shallow sample container, has been devised, and is described in the article. This method can also be applied to waxes where the relevant standard method has the same drawbacks as those indicated in the case of petrolatum. O. M.

834. An electrical viscometer. A. R. Boyle. *J. Sci. Instrum.*, 1950, **27**, 41.—A simple electrical viscometer has been designed; this enables instantaneous indications of viscosities of liq to be made at any point in an industrial plant. The transmitter unit consists of a two-phase electric motor operated from single-phase mains, and so designed and constructed that large variations of current in one phase are produced by small changes in viscous drag on the rotating part. The indicator unit is essentially an ammeter in one of the motor phases, and is directly calibrated in viscosity units. Models have been designed for operations within pipelines and containers up to high pressures and high temperatures (about 250° C) and for rapid testing of samples.
C. N. T.

Gas.

835. Improvement of laboratory gas burners. Anon. *Chemical Education*, Jan. 1950, **27** (1), 19.—Flame characteristics of natural gas are so different from those of manufactured fuel gases that a change in gas supply from manufactured to natural gas necessitates the alteration of all gas-burning appliances. The paper describes the changes which are necessary in Bunsen-type burners. A comparison of the dimensions of sixteen burners with the fundamental relations for good burner operation brought out three major reasons for their unsatisfactory performance on natural gas. These were: (i) too small port area, (ii) improper throat size, (iii) insufficient primary air opening. A. S.

Engine Fuels.

836. Effect of pressure on burning velocity. (*a*) F. H. Garner, G. K. Ashforth, and R. Long; (*b*) C. Tanford. *Nature*, 1949, **164**, 884. (*a*) Burning velocities (V) of benzene/air flames have been measured from shadow and direct photographs of the flame at pressures from 300 to 700 mm. It is found that: (1) the dia of the burner is not important in this pressure region; (2) V varies inversely as $(\text{pressure})^{0.25}$.

(*b*) The statement that $V \propto (1/P)^{0.25}$ (see also Abs. No. 1830, 1949) is not strictly true. $V \propto (\Sigma x_i/B_i)^{0.5}$, where x_i is the mol fraction of the active species at the equilibrium surface and B_i is a factor not dependent on pressure. But in hydrocarbon combustion, $x_R \propto (1/P)^{0.5}$ approx, and hence the relationship $V \propto (1/P)^{0.25}$ is not a true relationship. In the stoichiometric mixture butadiene/air, V decreases with pressure less sharply than the fourth-root relation would predict. The size of the burner diameter on V is discussed. H. C. E.

837. Sulphur content of catalytically cracked gasolines. M. S. Sterba. *Industr. Engng Chem.*, 1949, **41** (12), 2680–7. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem. 115th meeting Amer. Chem. Soc., San Francisco.*)—The study of factors affecting S content of cat cracked gasolines is prompted by increasing use of high S-bearing oils as cat cracking feed stocks. Relatively high S concns appear in cracked products with boiling range round 400° F. Low S contents in gasoline are favoured by low

reactor temp and high conversions. The S content is not greatly dependent on type of cat employed. Lead susceptibility is decreased by increased S or olefin content of cat gasolines. Mercaptan concn in debutanized gasolines are low relative to total S.
R. G. T.

838. Sulphur distribution in thermal cracking of high sulphur feed stocks. J. M. Barron, A. R. Vanderploeg, and H. McReynolds. *Industr. Engng Chem.*, 1949, **41** (12), 2687–90. (*Symposium on Sulphur in Petroleum. Divn of Pet. Chem. 115th meeting Amer. Chem. Soc., San Francisco.*)—Sulphur content of charge and gasoline is shown for thermal cracking several stocks from California, West Texas, Wyoming, Venezuelan, Mexican, and Arabian crudes. Prediction of S content of thermally cracked gasoline from S content of charge is enabled by a simple factor for each of the above crudes. Distribution of S between gas, gasolines, and bottoms from thermal cracking is shown for stocks from West Texas, Wyoming, and Arabian crude sources. Effect of conversion level on S distribution is shown for thermal cracking of Arabian gas oil.
R. G. T.

839. Lead fouling in internal combustion engines. C. G. Williams. *Rev. Inst. franç. Pétrole*, 1949, **4**, 645–52.—Problems caused by use of T.E.L. in fuels are discussed. Plug failures may be due to short-circuiting at the electrodes or to the shunting of the latter by a film of Pb compounds on the insulator. Trouble arises if such a film has a resistivity $<2 \times 10^5$ ohms. This can occur as low as 300° C with $PbBr_2$. Inter-cylinder T.E.L. distribution can be very uneven, due to its low volatility as compared with fuel; use of acetylene tetrabromide as a lead scavenger having a v.p. close to that of T.E.L. has given marked improvement over the more volatile ethylene dibromide. Exhaust valve troubles can be diminished by valve rotation or by coating with a Ni–Al–Co alloy. Other difficulties arising from Pb fouling include piston corrosion, pre-ignition, and lowering of permissible supercharge pressure. As much as 75% of sludge in aero-engine lub. oil can be Pb compounds. V. B.

840. Weak-mixture utilization in aero-engines. Adaptation of motor and fuel for weak-mixture operation of aero-engines. J. J. Broeze and C. Stillebroer. *Rev. Inst. franç. Pétrole*, 1949, **4**, 653–60.—Factors governing the ignition of weak mixtures are examined and experimental studies made on a CFR engine and on a single-cylinder aero-engine are presented. Sp fuel consumption decreases for mixtures slightly weaker than theoretical. Weak-mixture operation is of advantage in engines fitted with exhaust turbines, due to lower exhaust-gas temp. Fuel/air ratio does not influence duration of combustion period, but does affect delay between spark occurrence and pressure rise. Such delay is a min for a mixture slightly richer than theoretical. Delay in a weak mixture can be decreased by increasing mixture turbulence within the cylinder, *e.g.*, by use of screened valves. Improvement of ignition of weak mixtures by changes in fuel composition is not a promising approach, owing to the close similarity in this respect between all practicable fuels. It is suggested that weak-mixture operation for cruising can best be accomplished by improved ignition systems, controllable mixture turbulence, mixture layering (whereby the richest mixture is nearest to the sparking-plug), and improved mixture distribution between cylinders. The use in aviation of diesel engines coupled with exhaust turbines is advocated. V. B.

841. Manufacturing trials of aromatic aviation fuels. J. Givaudon and A. Guillemin. *Rev. Inst. franç. Pétrole*, 1949, **4**, 661–70.—A description and drawing are given of a fluid cat pilot plant (5–10 l/hr) in which aromatization experiments were carried out on a 75–148° C Iraq gasoline. Typical yield was 57·8% of aromatic (50%) dist, 20·4% gas (70–80% H_2), 20·8% coke, and 1% loss. The aromatic dist was hydrogenated to zero Br. No. without, however, affecting the aromatics. The approx composition of this material, as determined by fractionation and infra-red spectrography, is given. O.N. (clear) was 84. On blending with light (20–63·5° C) Iraq gasoline (40%) and adding 0·08% T.E.L. an O.N. of 92 was obtained. A suitable aviation gasoline was made up of 15% *iso*pentane, 15% *iso*-octane, 25% of the front end (up to 94° C) of a hydrogenated gasoline, and 45% of aromatic dist; with addition of 0·12% T.E.L. This had a performance index (F.4) of 131, together with other suitable characteristics. V. B.

842. Dual fuel engines. G. A. Keep. *Mech. World*, 17.2.50, **127** (3292), 177.—Dollar situation necessitates consideration of using alternative fuels in diesel engines. Alternative to oil is gas, and most common gases are coal gas, producer gas, and methane. During recent years much research work has been undertaken in production and use of methane, which is readily obtainable from digesting sewage. It has a gross cal. val. of 680 B.Th.U/cu. ft. and is quite suitable for use in i.c. engines. Explosive range for gas/air mixture is 5–15% methane, and engine air and gas valves are therefore normally set to give a mixture of about 12% gas to 88% air. Ignition is generally by magneto, and this is subject to a number of objections such as very high exhaust temp (about 1100° F), difficulty in starting from cold, and reduction in power due to reduced pressures. A development which has recently been the subject of considerable experiment is use of oil fuel for ignition purposes. With this arrangement the compression pressure is increased, and the magneto and plugs are replaced by a fuel-pump and spray nozzles. Probably greatest advantage of this system of ignition is the ability to change from gas to oil fuel without stopping the engine. Other advantages are listed. A. S.

843. Sulphur in diesel fuels. J. J. Broeze and A. Wilson. *Gas Oil Pwr*, 1949, **44**, 386–8.—The presence of sulphur in diesel fuels means that sulphur trioxide is formed in the combustion-chamber process, although not in the amounts sometimes reported. This leads to two effects : condensation of acid products in the cylinder, and adsorption on to the carbon particles, which converts the soot from a fluffy, voluminous character into a hard, abrasive substance.

The presence of acids leads to corrosion and wear, which is less in large, low-speed engines than in small, high-speed units. Since lubricating conditions are better in a four-stroke than in a two-stroke, the effect of sulphur is greater in engines of the latter class. Differences in the soot are reflected in more crankcase deposits and less piston cleanliness when a sulphur-containing fuel is used. Fouling of the injectors also occurs.

Reduction in corrosion can be obtained by keeping the cylinders warm, particularly when starting, and by warming up as quickly as possible, without, however, introducing fuel so quickly that incomplete combustion occurs. If the wall temp becomes too high lacquering and ring-sticking will take place. H. C. E.

844. Wide-cut diesel fuels safe for railroad locomotives. A. B. Crampton, S. H. Hulse, and N. H. Rickles. *Refiner*, Apr. 1949, **28** (4), 139–45.—The post-war expansion of the diesel-engine industry raises the question of the availability of sufficient fuel of requisite quality. Graphs and tables are presented showing the statistics on diesel-locomotive manufacture in the U.S., crude petroleum production as compared with proved reserves, and U.S. domestic demand for various petroleum products. It is shown that sufficient diesel fuel is available to meet the growing demand, provided certain problems are overcome. It is suggested that for many purposes (including railroad traction) specifications might be relaxed to provide a wider-cut diesel fuel of lower flash-point but normal cetane rating and other specifications. For many purposes a lower cetane rating could be tolerated.

Inspection data for typical wide-cut fuels are given, and extensive field tests are described comparing wide-cut fuels with conventional fuels. Experimental results are given on fuel consumptions, exhaust-smoke densities, max equilibrium fuel temp in locomotives, and min fuel flash points for safe refuelling of diesel locomotives.

It is concluded that the evidence presented, together with fifteen months' practical service show that a wide-cut, 130° F-flash-point fuel is completely safe and satisfactory for railroad diesel engines. W. E. M.

845. Performance of gas turbine fuels. J. G. Withers. *Rev. Inst. franç. Pétrole*, 1949, **4**, 636–41.—Wide-cut fuels are more suitable than kerosines, and also have the advantage of greater availability; best results are obtained with low-visc, high-volatility products. Cold test (as determined by pumpability and filterability rather than pour point) is one of the most important fuel characteristics. Slow running, which accentuates differences between fuels, leads to carbon deposits; such deposits are independent of C/H ratio and of S content. As little as 1% lub. oil in a kerosine fuel can double the amount of carbon deposit formed. For max combustion efficiency higher air/fuel ratios are required for more volatile fuels. V. B.

846. Gas turbine fuels. J. W. Drinkwater. *Rev. Inst. franç. Pétrole*, 1949, **4**, 642–4.—Present U.K. spec (D.E.R.D. 2482) for gas-turbine fuels requires max visc 6 cs at 0° F, min flashpoint (Abel) 100° F, 20% dist min at 200° C, F.B.P. 300° C max, pour −40° C max, aromatics 20% max, S 0·1% max, and cal. val. 18,300 B.Th.U/lb min. Tests were made on five fuels (inspections given), from which it is concluded that whilst a wide range of fuels will give satisfactory results, kerosine is, if possible supply difficulties are ignored, preferable. Gasoline is unsatisfactory owing to vapour lock and high evaporation losses. Indications are that the S content could be raised to at least 0·25% without ill effects. V. B.

847. Requirements of jet fuels. E. Eltham. *World Petrol.*, 1950, **21**, (1), 29–31.—Current and proposed jet fuel spec are discussed. Suggested v.p. of 5–7 p.s.i. is considered excessive owing to risk of boiling at high altitude. New U.S. spec for wide-cut fuel results in explosive limit being lowered by 140° F compared with earlier kerosine fuel. Low-temp properties are important, and waxes with m.p. $> -76°$ F should be excluded. A variable-area fuel nozzle giving const pressure independent of altitude has recently been developed; operation is independent of fuel visc, which should avoid "hot starts" occurring at low temp. E. B.

848. Patent. A. Farkas, assr to Union Oil Co. U.S.P. 2,493,284, 3.1.50. A diesel fuel consisting of a hydrocarbon fraction boiling within 300° F to about 800° F and 0·1–5% by volume of an oxidized organic sulphur compound. C. F. S.

Gas Oil and Fuel Oil.

849. 1948 fuel-oil consumption, United States Bureau of Mines. Anon. *Fuel Oil & Oil Heat*, Jan. 1950, **9** (1), 84.—Sales of distillate fuel oils and kerosine in the U.S.A. reached new heights in 1948. Demand for distillate grades expanded by 14%. Residual-fuel-oil sales were about 4% below 1947 figures. Kerosine sales were 10% above those of 1947. Total deliveries of light heating oils were 12% above the 1947 total. Light fuel oils used for space heating accounted for 59% of total sales in 1948. The market for heavy grades of heating oils made up about 11% of all demands. Sales and demand for the various grades in different areas of the U.S.A. are discussed. Tables of data are presented. D. K.

Lubricants.

850. Friction measurements on test machines and their value in estimating lubricating power of oils. G. Vogelpohl. *Erdöl u. Kohle*, 1949, **2**, 551–7.—Possibility is discussed of arranging lubricants in order of their friction-reducing properties by testing them on various machines, and a brief survey of previous work in this field is presented. Results are influenced by the method of feeding the sliding surfaces with lubricants. Because of this and of the difficulty in estimating accurately the visc of the lubricating film, it is suggested that reliable information will be obtained only when the conditions in the test apparatus are not appreciably different from those in the actual equipment in which the lubricant is to be used. A. C.

851. Low temperature flow resistance tests for lubricating oils. G. L. Coulter and L. C. Borell. *Refiner*, Mar. 1949, **28** (3), 122–4.—It is shown that the A.S.T.M. pour-point of a lube oil does not indicate the fluidity of the oil at low temp. To meet this difficulty, an apparatus is described for measuring the flow resistance of lubes at temp approaching the pour-point. The apparatus is similar in principle to the Redwood instruments. Experiments are described on the influence of viscosity, V.I., wax content, and depressant content of the lube, upon the measured flow resistance. W. E. M.

852. Soluble cutting oils for turning. Anon. *P.E.R.A. Bulletin*, Feb. 1950, **3** (2), 59.—Cutting fluids are used to reduce machining costs by increasing tool life or cutting speeds or both. The report compares the effect of eleven soluble cutting oils on tool life when turning with cemented carbide and high-speed-steel tools. The criterion

used for comparing the emulsions in the tests on carbide tools was the vertical wear on the flank of the tool after cutting for a given time under closely controlled conditions. The tests with high-speed steel tools were continued until the tool failed. A summary is given of the results obtained. It is recommended that when using cemented carbide tools and turning tough or high tensile steels, a soluble oil is to be preferred to cutting dry. For mild steels and cemented carbide tools dry cutting is recommended, because any advantage gained in tool life by using soluble oils is offset by the disadvantages of corrosion risk to the machine tool, spray, etc. A. S.

853. Sulphurized extreme-pressure lubricants and cutting oils. H. Sellei. *Petrol. Process.*, 1949, **4**, 1003–8.—This paper is a literature survey on sulphurized oils and sulphur compounds with particular reference to E.P. lubricants and cutting oils. The theoretical background of boundary lubrication is presented, together with the theories on the mechanism of sulphurized lubricants. W. E. M.

854. Sulphurized extreme-pressure lubricants and cutting oils. H. Sellei. *Petrol. Process.*, 1949, **4**, 1116–20.—This paper presents a comprehensive survey of patent literature on sulphurized oils and sulphur compounds, with particular reference to E.P. lubricants and cutting oils. W. E. M.

855. Dry film lubrication. Anon. *Mech. World*, 3.2.50, **127** (3290), 119.—Considerable strides have been made in past ten years in technique of lubricating rubbing surfaces by means of dry slippery films. It has been shown that formation of oxide, sulphide, and other products on steel rubbing surfaces brings about a reduction in coeff of friction. Reason for this is not clear, but various explanations have been offered which rely on fact that oxidn products on a metal surface discourage adhesion of rubbing faces. Recent studies by the N.A.C.A. of the U.S.A. have confirmed important facts about graphite films in lubrication. Experiments showed that for lubricating dry films, friction coeff of rubbing faces falls sensibly with increasing speeds. There is also no appreciable increase in coeff of friction for increasing loads up to moderately high values. A dry film will not satisfactorily cool rubbing faces where heat other than that due to friction is present, and in such cases circulating oil is essential. For light mechanisms and instruments dry lubrication is efficient, and it is widely used under conditions of high temperature (up to 600° C). Graphite films have also been used by one aero-engine manufacturer for bench testing and running-in. There is undoubtedly an important part to be played in the future by thin graphite films. A. S.

856. Gas compressor lubrication. F. M. McCall and E. H. Flaherty. *Oil Gas J.*, 2.2.50, **48** (39), 63.—Factors contributing to the problem of lubricating compressor cylinders and piston-rod packing are discussed. General headings include ratio of compression at which cyl is operating, operating pressure and jacket-water temp of cyl, type of gas, single-stage of multi-stage operation, amount of dirt and contamination in gas, and correct maintenance of equipment.

Problem of lubrication with a dry, sweet gas is not great, as hard deposits are not usually formed on valves, and a light-viscosity oil can be used.

The presence of constituents likely to wash oil from cyl walls and piston-rod will necessitate supply of oil in quantities sufficient to keep walls well flooded.

Type of gas being pumped and its discharge pressure must be considered when the machine is operating single-stage and multi-stage.

Dirt carried along by gas may cause abrasion, interfere with ring and valve seating, and promote oil oxidation or decomposition.

A compressor handling dry, sweet gas at moderate compression ratios requires about a pint of oil for each 2 million sq. ft. of surface swept per day. G. A. C.

857. Molybdenite as a lubricant. A. H. Stuart. *Auto Engr*, Feb. 1950, **40** (524), 72.—Rise in operational temperatures in recent years has directed attention to use of dry films for lubrication purposes. Among recent additions to list of dry films molybdenite has been tested, and experimental work has revealed not only its merits but also its limitations. Its structure is of the layer formation like graphite, and consists of a layer of molybdenum atoms with a layer of sulphur atoms on either side of it. In addition to contributing to its lubricating properties this molecular formation has the

effect of rendering it very adhesive to most metallic surfaces owing to the chemical bonds between metal and sulphur. Experimental work has shown that a film of molybdenite on one member of stainless steel running on copper–lead bearing alloy reduced friction by nearly 60%. It is also claimed that molybdenite is stable at high temperatures, but this is only the case when there is an absence of oxygen. Also when molybdenite burns it produces molybdenum trioxide and sulphur dioxide, so that if there is any moisture present corrosive sulphurous acid will be produced and molybdenum trioxide which is a powder with abrasive properties. Great caution is therefore necessary in the employment of molybdenite as a lubricant in cases where high temperatures may be encountered in the presence of air. A. S.

858. Lubricants in mining. W. Reuschle. *Erdöl u. Kohle*, 1949, **2**, 558–63.—Lubricant consumption in German mining industry is 1000–2000 tons/month. General considerations governing lubrication of mining equipment are surveyed, including brief remarks on oil recovery. V. B.

859. Greases from first- and last-runnings of fatty acids from paraffin wax oxidation. H. Kölbel and D. Ullmann. *Erdöl u. Kohle*, 1950, **3**, 16–21.—In the production of synthetic fatty acids for soap manufacture the lower (C_4–C_9) and higher ($C_{>20}$) acids are by-products neither of which, on their own, yield suitable greases. A mixture (40% lower, 60% higher) of the acids is a good base for Ca and Na greases. Na soaps from the higher acids alone are too soft, but addition of lower-acid Na soaps increases drop point of the grease and improves storage stability. Roller-bearing greases with drop point 220° C but soft at room temp are thus obtainable (total fatty acids 12·6%, divided as to 60% lower, 40% higher, oil component 3·5° E at 50° C). Similar drop-point-raising effect is shown by formates and acetates, both for Ca and Na greases. Mixed Na + Ca greases from the fatty acid mixture yield good-quality water-resistant roller-bearing lubricant. Tests on ball-bearings showed good results for greases made from the mixed acids. A theoretical explanation of the findings is put forward. V. B.

860. Extreme temperature lubricating greases from silicones and silicone-diester mixtures. R. L. Merker and W. A. Zisman. *Industr. Engng Chem.*, 1949, **41** (11), 2546–51.—Dispersion of lithium stearate in the several types of silicone fluids with the aid of volatile mutual solvents has enabled the preparation of a new and useful class of lub. greases. Mutual solvents are, *e.g.*, aliphatic esters of dicarboxylic acids. Greases made from these mixtures resembled in texture and properties the greases prepared from pure diester fluids and lithium stearate. These two classes of greases are characterized by good stability to heat, oxidation, and friction and low syneresis and evaporation rates. They lubricate effectively between −60° and 325° F when silicones alone are used and between −130° and 250° F when silicone diester mixtures are used. R. G. T.

861. Additives in aero-engine oils. S. A. W. Thompson. *Rev. Inst. franç. Pétrole*, 1949, **4**, 691–6.—Restrictive influence of military aero-engine oil spec which ban additives is discussed. Potential supply difficulties, the reason for such a ban, do not apply to civil aviation. Use of additives in aircraft oils is purely an economic question; whilst the power output of present-day civil aircraft engines does not make such use essential it may be worth while by increasing inter-overhaul period or pay-load (*e.g.*, by permitting a wt decrease in reduction gearing by use of film-strength improvers). V. B.

862. Synthetic aero-engine oil that has shown good performance. L. Hemmer. *Rev. Inst. franç. Pétrole*, 1949, **4**, 676–82.—Synthetic lub oils made by alkylation of aromatic nuclei are more stable than those produced by polymerization of α-olefins, but have a less favourable V.I.–pour-point relationship. Alkylation of aromatics with long-chain paraffins yields oils showing properties of auto-inhibition of oxidn. A synthetic lub. oil of good quality can be obtained by alkylation of aromatics (commercial benzene) by polymerized α-olefins, the reaction occurring in presence of $AlCl_3$. As source of α-olefins there was used the 50–315° C cut obtained by cracking de-oiled paraffin wax. The oil produced had visc 25·2 cs at 210° F, V.I. 107 and pour −36° C. 2–2·3 tons of de-oiled wax are required per ton of oil, assuming a 60% yield of olefinic dist on

cracking. 50-hr bench test on a six-cyl air-cooled aero-engine showed synthetic oil to have excellent performance as compared with an approved mineral oil. Cost of synthetic oil is, however, 30–40% higher, and it is considered that Middle East crude will, owing to its chemical composition, yield by normal refining methods lub. oils having similar properties. V. B.

863. Lubricants for aviation gas turbines. C. S. Windebank. *Rev. Inst. franç. Pétrole*, 1949, **4**, 683–90.—Lubrication requirements of turbo-jet and turbo-prop engines can be met with the same oil. Owing to reduction gearing in the latter type of unit an oil of high film strength is required. A suggested spec calls for the following characteristics: visc (cs) 9 min at 210° F and 5000 max at −40° F (= V.I. of 170 min), pour −40° F, flashpoint (open) 400° F min, film strength 100 lb min, film endurance at 80 lb 15 hr min. Latter two tests are carried out in the I.A.E. tester. The reasons for the various above requirements are individually discussed. Use of E.P. additives is undesirable owing to prospective future bearing temp being as high as 450–500° F. An experimental synthetic oxygen-containing lub. oil ("EEL-3") has been produced on the pilot-plant scale, and whilst not meeting the visc requirements of the above spec, appears, as a result of bench tests, to be a suitable lubricant. V. B.

864. Patents. M. S. Altamura, assr to Socony-Vacuum Oil Co. Inc. U.S.P. 2,493,213, 3.1.50. A lubricant comprising a mineral oil fraction and having a minor proportion, 0·01–1·0%, of triethyl-lead caproate.

H. G. Berger, E. W. Fuller, assrs to Socony-Vacuum Oil Co. Inc. U.S.P. 2,493,216, 3.1.50. An improved mineral oil composition having about 0·5–10% oil-soluble metal sulphonate, 0·1–3·0% oil-soluble, phosphorus- and sulphur-containing reaction product obtained by reaction of phosphorus sulphide and a dicyclic terpene material, and 0·25–2·0% of a similar reaction product obtained by reaction of 1 mol phosphorus pentasulphide and 4 mol of oleyl alcohol.

H. G. Berger, E. W. Fuller, assrs to Socony-Vacuum Oil Co. Inc. U.S.P. 2,493,217, 3.1.50. An improved mineral oil composition having mixed therewith 0·5–10% oil-soluble, sulphurized metal carboxylate, 0·10–3·0% oil-soluble, phosphorus- and sulphur-containing reaction product obtained by reacting a phosphorus sulphide and a dicyclic terpene material.

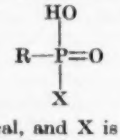
C. E. Francis, R. C. Jones, assrs to Shell Development Co. U.S.P. 2,493,483, 3.1.50. A marine engine lubricant capable of forming stable emulsions when in contact with an aqueous medium comprising 0·05–1% of a glyoxalidine, 0·01–1% of metal sulphonate, 0·05–1% of a partial ester of polyhydric alcohol and fatty acid, 0·1–5% of fixed fatty oil, and the balance being mineral oil. C. F. S.

Bitumen, Asphalt, and Tar.

865. Some further advantages of asphalt as a road-surfacing material. C. G. Smith. *King's Highway*, Jan. 1950, **17** (1), 19.—The progress of road-making through the ages is described, commencing with soil and proceeding with stone, water-bound macadam, tar macadam, and finally, asphalt. The following properties of asphalt as a surfacing material are important: (1) waterproofing qualities; (2) stability; (3) non-skid qualities; (4) durability; (5) noiselessness; (6) hygienic qualities; (7) colour.

Details of these are given. Finally, a description of various types of asphalt surfacing (rolled asphalt, rock asphalt, and paving mastic) is given. R. H.

866. Patent. D. Harman and H. J. Sommer, assrs to Shell Development Co. U.S.P. 2,492,994, 3.1.50. An asphalt composition predominantly asphalt and having 0·1–5·0% by weight of an acid having the structure



R is an aliphatic hydrocarbon radical, and X is a radical of the group hydrogen, a hydroxyl group, and a hydrocarbon radical. C. F. S.

Special Hydrocarbon Products.

867. Petroleum resins and oils gain in coatings field. R. R. Ruthruff. *Chem. Ind.*, Nov. 1949, **65** (5), 722.—Many by-products from petroleum refining contain bodies which polymerize to form resin-like materials. In the normal way these are burnt by the refinery, and therefore command only fuel-oil value.

In view of the drying oil and resin position, which has become critical not only from the economic angle but also from the question of supply, considerable effort has been expended over a relatively long period to develop, from the polymerizable materials, products which can compete with naturally occurring oils and resins on both cost and quality bases.

Resins produced direct from these refinery by-products, such as bottoms from the distillation of catalytically cracked gasoline, are of low quality, and therefore attention was turned to the use of these purely hydrocarbon materials as feedstock for other processes. An example of this is the employment of " drip oil," from the manufacture of ethylene glycol from gaseous hydrocarbons, in the production of resins similar to the conventional coumarone–indene resin. Again, the use of catalytic aromatization in the petroleum field yields a polymer which contains alkyl aromatics which are very useful in the production of formaldehyde resins.

In addition to the above resin types, petroleum by-products can also be used in the non-hydrocarbon field of resins as exemplified by polyvinyl chloride and epichlorhydrin/phenol. O. M.

868. Petroleum base protective coatings. (A Staff Industry Collaborative Report.) W. H. Shearon, Jr., and A. J. Hoiberg. *Industr. Engng Chem.*, 1949, **41** (12), 2672–9.—This survey is introduced by a historical account of use of asphaltic coatings. Recent developments by the Lion Oil Co. are followed by a general survey of asphalt coating manufacture, including a process flow sheet. Properties of the finished coating are described. Two broad classes of rust preventives are recognized, non-drying types and those which dry to a hard film. A different classification according to type recognizes three groups : preservative oils, semi-solid, and solid (generally waxes) and solvent types. Rust-preventive problems are discussed, and manufacturing steps are supplied. Properties are tabulated extensively, and future prospects are discussed. R. G. T.

Derived Chemical Products.

869. Nitrile rubbers as plasticizers in vinyl resins. M. C. Reed. *Mod. Plastics*, Dec. 1949, **27** (4), 117.—Conventional plasticizers for vinyl resins, such as esters and ketones, suffer from the disadvantage of being removed from the plastic product by volatilization or by extraction by solvents, oils, and water.

This difficulty is not encountered when nitrile rubber is used as plasticizer. These rubbers appear to plasticize vinyl resins by solvation and, when they are used, vulcanization of relatively low-resin-content products is desirable. Because of their low plasticizing efficiency, nitrile rubbers are best suited to resin products having high or medium stiffness.

Normal stabilizers are effective with nitrile-plasticized resins, but anti-oxidants must be included in the formulation, though these do not prevent deterioration due to weathering, etc.

Vinyl mixes containing nitrile rubber can be processed normally, but if no solvent is used it is best to cold mill the mix before it is fed to the hot mill. Co-precipitation with vinyl resin emulsion or suspension can be utilized satisfactorily.

When calendering vinyl-nitrile rubber blends low temperatures are recommended, and, for extrusion, temperatures should, in general, be kept 5 or 10° C lower than for components plasticized with esters. O. M.

870. Aldehydes from hydrocarbons. P. W. Sherwood. *Petrol. Process.*, 1949, **4**, 794–800.—Processes involving the partial oxidation of hydrocarbons to formaldehyde and acetaldehyde and the OXO process are discussed. W. E. M.

871. Evaluating detergents. Anon. *Soap Sanitary Chemicals*, Jan. 1950, **26** (1), 69.—Brief notes are given of a paper presented by H. J. Wollner at the American Oil Chemists' Society meeting in the autumn of 1949 on the evaluation of detergents for laundry use.

An essential element in all detergent evaluation is to define the conditions under which the detergent will be employed and to reflect these conditions, in so far as their total effect is concerned, in the laboratory test.

The factors which affect the performance of a detergent in a wash-room are enumerated. W. H. C.

872. Principles of detergency. Anon. *Soap Sanitary Chemicals*, Jan. 1950, **26** (1), 71.—A digest of a paper by E. K. Goette (*J. Coll. Sci.*, 1949, **4**, 459) describes the mechanism by which a detergent accomplishes the removal of dirt from a fabric. The effect of number of carbon atoms in a homologous series on wetting and detergency is described. The effect of branches in the paraffin chain on wetting and cleaning is discussed. The importance of interfacial tension between the soiled surface, the dirt and the aqueous solution, and the effect of the critical micelle concentration on the washing process are described and discussed. W. H. C.

Miscellaneous Products.

873. Guide to pigments and related products. J. H. Martin and W. M. Morgans. *Paint Mnfr*, Feb. 1950, **20** (2), 63.—Brief notes are given on the following: green B, naphthol; green B, pigment; green, Brunswick; green, chromastral; green, chrome; green, earth; green, emerald; green, lime; green O, fast; green, Paris; green, zinc; Guignet's green; Gulf red; Gutzeit test; gypsum; H-acid; haematite; halide; halogen; hammer mill; Hansa orange R; Hansa yellow; Hardinge mill; heavy spar; Helianthine; Helio Bordeaux B.L. D. K.

874. Stabilization of polyvinyl chloride. R. E. Lally and F. R. Hansen. *Mod. Plastics*, Dec. 1949, **27** (4), 111.—The most stable polymers and co-polymers of vinyl chloride are those which have undergone a high degree of polymerization. However, this state often raises processing difficulties or else is not suitable for the application involved. Therefore, the lower polymers have to be used, and these suffer in varying degrees from light and heat instability which results in the deterioration of the product. The intermediate product usually formed during this deterioration is hydrochloric acid or, alternatively, free radicals are produced which initiate chain reactions. No one stabilizer which will prevent deterioration from all possible causes has yet been found, but most of them appear to be active against both heat and light instability. Their main function is to react with any hydrochloric acid formed so that it is removed from the system before it can initiate other harmful reactions.

Examples of heat stabilizers are the soaps of barium, calcium, strontium, lead, and tin. Basic soaps are sometimes preferred, since in reacting with hydrochloric acid they do not produce fatty acids. Again, where toxic properties are important, the resin formulation is often built round a non-toxic stabilizer to obviate the necessity of searching for such a stabilizer to suit the formulation. Other heat stabilizers are the basic inorganic sulphates, carbonates, phosphates and titanates, organic compounds containing the epoxy grouping, and amines. A very interesting phenomenon exhibited by most of these stabilizers is synergism, where mixtures of them show more activity than either component alone.

Light stabilizers are exemplified by cadmium soaps, such as the ricinoleate and alkali phosphates, while ultra-violet screening activity is shown by such compounds as phenyl salicylate.

Choice of stabilizer depends on three main factors, namely, formulation, processing conditions, and end use of the vinyl article. The final decision on suitability must be based on results of practical tests such as those laid down in tentative A.S.T.M. methods, which are described in the article under review. O. M.

875. The toxicity of solvents. A. J. Amor. *Paint Mnfr.*, Feb. 1950, **20** (2), 53.—Common property possessed by most volatile solvents is, if inhaled in sufficient quantity, that of producing anæsthesia. Henderson and Haggard classified gases and

vapours into six groups, according to their physiological action: (*a*) primary anæsthetics, *e.g.*, paraffins, ethers, etc., (*b*) anæsthetics which also injure distant organs, *e.g.*, some chlorinated hydrocarbons, (*c*) anæsthetic vapours which may injure blood-forming organisms, *e.g.*, benzene, (*d*) anæsthetic vapours which may injure the nervous system, (*e*) substances whose systemic effects overshadow their anæsthetic action, *e.g.*, organic nitro compounds. The sixth group refers to irritants. The various stages between consciousness and unconsciousness are listed. A table of toxic concentrations of various gases, dusts, and fumes in the atmosphere is also presented.

Solvents are classified chemically in the following groups: alcohols, amides and amines, esters, ethers, furans, glycols, halogenated compounds, hydrocarbons, ketones, nitriles, nitrohydrocarbons, and sulphur derivatives.

The first five groups are discussed, and tables of data of the toxic effects of individual numbers of the groups are given. The article is to be continued. D. K.

876. Photocolorimetric study of adsorption by carbon blacks. J. J. Trillat and J. Millet. *Rev. Inst. franç. Pétrole*, 1950, **5**, 9–12.—A known wt of carbon black is added to a solution of known concn of tar oil in benzene. After agitation (20 min) the black is filtered off and the extinction coeff of the solution determined photo-electrically and compared with the original val, yellow light being used. The decrease in opacity is thus measured, enabling the amount of oil adsorbed to be calc. Agitation time >15 min does not increase the amount of oil adsorbed. Curve of % of oil adsorbed against wt of black added is parabolic. Tests with tar-oil fractions indicate that the lighter components are preferentially adsorbed. The procedure described enables various grades of carbon black to be differentiated. Tests with a const quantity of black and solutions of increasing concn indicate that adsorbed oil layer can be polymolecular. V. B.

CORROSION.

877. The cost of corrosion to the United States. H. H. Uhlig. *Corrosion*, 1950, **6** (1), 29.—The annual U.S. direct loss by corrosion including cost of corrosion control is at least $5427 million. The contributing factors, protective measures, and trend of the future research are outlined. Nineteen references. J. T.

878. Experience with condenser tubes at a major oil refinery. S. van der Baan. *Corrosion*, 1950, **6** (1), 14.—The performance of product condensers and steam condensers at Curaçao Refinery of the C.P.I.M. (Royal Dutch–Shell Group) is discussed. These condensers are served with seawater from Schottegat Bay which has a pH of 7·0 (instead of 8·3 for fresh seawater) and high percentage of fine suspended matter. The temp varies between 27° and 32° C, and the water often contains free air. Cavitation due to air impingement, corrosion by acidic condensate, dezincification, stress and fatigue corrosion, and high-temp attack are discussed. Under prevailing conditions, aluminium brass of good quality is a versatile and economical condenser-tube material. Full-length annealing to a Brinell hardness of 100 and formation of an oxide film are probably beneficial. J. T.

879. Boiler corrosion and boiler feed water treatment. H. Hillier. *Trans. Inst. mar. Engrs*, 1950, **62** (1), 1.—Corrosion is a phenomenon which takes place in widely different and varied forms, but the cause is fundamentally the same in all cases. The paper explains the fundamental factors of the electro-chemical action which causes corrosion and describes and illustrates the main types of corrosion which take place inside boiler equipment. It shows that the two critical factors in boiler corrosion are the hydrogen-ion concentration and the presence of dissolved oxygen. The question of eliminating dissolved oxygen in feed and boiler systems is discussed, and recommendations are made for doing this. Also dealt with are the factors affecting the electrode potential of iron and the conditions necessary to obtain immunity from corrosion, together with the treatment of boiler water to avoid scale formation and to prevent corrosion. Basic data are given concerning the substances and reactions involved in feed- and boiler-water conditioning and the phenomena of scale formation. The basic facts of carbon-

ate and phosphate conditioning, colloidal and coagulant treatment, oxygen scavenging, caustic cracking, etc., are dealt with, together with the control of the hydrogen-ion concentration of the boiler water. A. S.

880. Influence of oil in subsurface corrosion of oilfield equipment. W. F. Rogers. *Oil Gas J.*, 15.12.49, **48** (32), 73.—The influence of wetting power of crude oils and of the water–oil ratio on corrosion rates has been investigated.

Wetting power was measured by a sessile drop method. Metal specimens were placed in a clear glass cell contained in a water-bath. Oil drops are placed on the lower side of the specimen by means of special pipettes. Droplet sizes are measured immediately the drops are placed and again after 3 hr. Metal surfaces are carefully prepared by grinding, polishing, washing in carbon tetrachloride, boiling in caustic soda solution in the presence of zinc, dipping in 10% sulphuric acid, and washing in distilled water. Corrosion rates were determined by shaking a steel specimen with the water and oil under test. To determine whether tubing is oil wet or water wet an electric logging apparatus was used to determine the surface resistance of the equipment.

It is concluded that :—

(1) Oils of high drop-size ratios do not tend to wet steel in the presence of water, but permit the metal surface to be wetted by a non-protective water film.

(2) As the drop-size ratio of an oil is decreased the protective effect is increased. Suitable amounts of wetting agent to decrease the drop-size ratios may be determined by experiment.

(3) Some oil-well brines, both sulphide bearing and sweet, are non-corrosive regardless of whether the tubing is oil or water wet.

(4) Some oil-well brines, sulphide bearing and sweet, are corrosive. Only if equipment is oil wet will it be protected.

References are appended. C. G. W.

881. Mechanism of oxygen reduction at an iron cathode. W. A. Patrick and H. B. Wagner. *Corrosion*, 1950, **6** (1), 34.—The mechanism of anodic corrosion is briefly outlined. Reference is made to previous articles wherein hydrogen peroxide was assumed to be an intermediate product, especially where ferrous compounds are involved. Experiments carried out with iron-amalgam cells are discussed, and description of the apparatus is given. A number of tables are included showing the present data on current, current density, percent absorption upon cathode solution, and percent yield of hydrogen peroxide. These data show that the largest yields of peroxide are obtained in alkaline solutions with small current densities. Hydrogen peroxide was possibly also formed in the acidic solutions, but was more quickly reduced further to hydroxyl ion, which reacted to form water. Instability of hydrogen peroxide at the cathode in acid solution in contrast to its greater stability in alkaline solution may be due to the fact that in the former case the peroxide would exist almost entirely in molecular form, whereas in the latter case it would exist largely as the peroxyl ion which is negatively charged, and upon migration from the cathode prevents further reduction, a situation that would not develop in the case of neutral peroxide molecule.

Fifteen references. J. T.

882. Corrosion of wet steel by hydrogen sulphide–air mixtures. D. C. Bond and G. A. Marsh. *Corrosion*, 1950, **6** (1), 22.—The most corrosive H_2S–air mixture for mild steel consists of about 1% H_2S in water-saturated air. At a 10% concentration of H_2S in air the corrosion increases by about 20% when the temperature is increased from 70° F to 120° F. During the first several hours of exposure the corrosion rate appears to be independent of time. Analysis of the corrosion products has shown that free sulphur is present even at high H_2S concentrations and that the percent sulphide increases fairly uniformly with increase in H_2S concentration. After 4 hr exposure to air at 120° F the oxidn of wet ferrous sulphide is 85·5% complete. Spontaneous ignition in air of ferrous sulphide prepared in these experiments does not take place. Under the conditions used in the experiments the conversion of hydrated iron oxide to iron sulphide (in the presence of hydrogen sulphide) proceeds faster than the conversion of iron sulphide to iron oxide in the presence of air. J. T.

883. Effect of adsorbed polar organic compounds on activity of steel in acid solution. N. Hackerman and E. L. Cook. *J. Electrochem. Soc.*, 1950, **97** (1), 1.—Aliphatic acids, amines, esters, and one commercial corrosion inhibitor were adsorbed from benzene solution on to 150–200-mesh S.A.E. 1020 steel powder. The protective character of the adsorbed material against attack by 4*N*-HCl solution was indicated by the rate of dissolution of metal in acid and the liberation of hydrogen. The acids and amines were more effective as inhibitors than alcohols and esters. The C_{10} compounds in the acid, amine, and alcohol series showed optimum effectiveness. J. T.

884. Corrosion—inhibited fuels. J. M. Michel and K. F. Hager. *Industr. Engng Chem.*, 1949, **41** (11), 2616–22.—Known methods and recent advances in the field of corrosion prevention in pipelines, storage containers, tanks, and other equipment are surveyed. Admixtures to the fuel to produce surface passivity promise extended technical application and advantages over proper choice of materials of construction, or surface protection by suitable treatment. Research starting in mid-1930s is reported, especially on use of fluoride for fuel containing T.E.L. in contact with light-metal tanks in airplanes. Investigations on emulsifying agents led to the surprising discovery that a small addition of mepasin–sulphamido–acetic acid–sodium salt to the fuel prevents any corrosion. [The term " mepasin " applies to hydrocarbon fraction from Fischer–Tropsch synthesis with chain lengths from 12 to 18 carbon atoms.] Construction can therefore be guided solely by the choice of mechanical and thermal properties. R. G. T.

885. Corrosion protection for tanks by reinforced gunite linings. Anon. *Petrol. Process.*, 1949, **4**, 784–8.—It is shown that reinforcing gunite layers with steel mesh enable the application of thicker layers which have longer life and better corrosion-resisting properties. W. E. M.

886. Preparation of pipe surface for bitumen coating during reconditioning. O. C. Mudd. *Corrosion*, 1950, **6** (1), 19.—The exterior cleaning of a pipe after removal from soil for reconditioning is costly. The three common cleaning methods are mechanical cleaning, sand or grit blasting, and to a smaller extent flame cleaning. A pipe taken out of the ground is often covered by strongly adhering siliceous material which resists removal by ordinary cleaning. Instead of complete removal of such particles, it is suggested that after preliminary cleaning a solution made from one part bituminous primer and four parts thinner should be applied. This materially improves the final primer coating bond. Water-repellent and corrosion-inhibiting compounds added to the dilute primer solution will improve its dehydration and protective properties. J. T.

887. Patent. P. L. Menaul, assr to Stanolind Oil and Gas Co. U.S.P. 2,493,462, 3.1.50. Inhibiting corrosion in wells by mixing with brines a small amount of bone oil. C. F. S.

Engines and Automotive Equipment.

888. Influence of chemical and turbulence factors on the combustion process under engine-operating conditions. A. S. Sokolik, A. N. Voinov, and Yu. B. Sviridov. *Izvest. Akad. Nauk S.S.S.R.; Otdel. Tekh. Nauk.*, 1949, 1848–73.—Details are given of a special experimental motor-driven, single-cyl engine with a transparent cyl-head and fitted with automatic photo-recording and indicating equipment. Accurately prepared fuel/air mixture is fed through a specially designed port so that combustion within the cyl can be observed under strictly controlled conditions. Fuels used were benzene, *iso*-octane, and an S.R. aviation gasoline. Combustion rate can be measured by sectional photographs of the combustion space. Influences of the following factors were studied : direction of movement of charge on flame distribution, ignition advance on flame velocity, and turbulence. Combustion can be divided into three phases : initial, in which the flame front is established and the duration of which is determined by the basic (chemical) flame velocity and minor turbulence effects controlled largely by engine speed, the main phase, in which combustion rate depends only on the

development of the flame surface by major turbulence effects which bear a linear relationship to engine speed, and the third phase (not investigated) in which combustion rate depends solely on the basic (chemical) flame velocity. The relative approx charge vol involved in these phases are 15, 75, and 10% respectively. Equations are derived showing the relationship of the various factors in each of these three phases. The conclusions drawn by Ricardo that the initial phase of combustion is independent of engine speed is criticized. Although increased turbulent combustion rate in the ignition zone is desirable, it has the effect of rendering ignition more difficult. V. B.

889. B-Type Petter small engines. Anon. *Gas Oil Pwr*, 1949, **44**, 376.—These four-stroke units are made in sizes from two to four cyls to cover the power range 12–36 b.h.p. at 1000–1500 r.p.m. The cyls have 4·33 in bore and stroke, and the b.m.e.p. is 75 p.s.i. A hemispherical cavity in the Al-alloy piston forms the combustion chamber, and the piston has five rings, of which the top one is chromium plated, and the fourth and fifth are stepped and slotted scraper rings respectively. A gear-type oil-pump applies lub. oil to all main bearings, and the cyls, small ends, and camshaft are splash lubricated. Details of the engine construction are given. H. C. E.

890. Jet laboratory nears completion. Anon. *Heating and Ventilating*, Jan. 1950, **47** (1), 95.—The new Andrew Willgoos Turbine Laboratory, designed and built expressly for testing experimental jet engines, is complete except for installation of a few major pieces of equipment. It will go into operation within the first three months of 1950. The new laboratory has four test cells for testing engines or engine components, and air can be cooled to minus 70° F and thinned to an equivalent of that found at the cold reaches of 40,000 ft. Four turbo-generators supply a total current of 18,400 kW. A. S.

891. P. 1052-Hawker swept-wing experimental fighter. Anon. *Flight*, 9.2.50, **57** (2146), 189.—Details are given of the Hawker swept-wing experimental fighter for high-speed research. The plane is powered by one Rolls-Royce Nene II turbo-jet. Cut-away drawings are given of some structural details. I. G. B.

892. A high power 2-cycle sleeve valve engine for aircraft. G. F. Hiett and J. V. B. Robson. *Airc. Engng*, Feb. 1950, **22** (252), 32 (*contd. from p.* 23).—This is a description of the development of the two-cycle petrol-injection research unit built and tested in the laboratories of Messrs Ricardo & Co. I. G. B.

893. Britain's first jet bomber. Anon. *Aeroplane*, 10.2.50, **78** (2018), 153.—The English Electric Co. Canberra B Mk. I was seen for the first time at the S.B.A.C. display last September. Details of the internal arrangements and part of the equipment of the aircraft are described, although weights and performance are not available. The engines are two Rolls-Royce Avon axial-flow turbine engines. I. G. B.

894. Comparison of various methods of thrust augmentation for turbo-jet engines. E. W. Hall. *Aero. Engng Review*, Jan. 1950, **9** (1), 25.—A theoretical comparison has been made of various methods of thrust augmentation for turbo-jet engines. The methods investigated were tail-pipe burning, water injection at the compressor inlet, a combination of tail-pipe burning plus water injection, bleed-off in conjunction with water injection at the compressor inlet, and rocket assistance. I. G. B.

895. Diesel air intake systems. T. G. Hicks. *Mech. World*, 10.2.50, **127** (3291), 161.—Clean air reduces diesel piston, liner, ring, and bearing wear, while dusty air and intake restrictions can double maintenance costs, reduce power output, and shorten engine life. Even in supposedly dust-free areas the atmosphere often contains particles which are harmful to engines. Various types of intake-air filters are described, and sketches are given of the following types: (*a*) dry type with felt filter-elements; (*b*) viscous impingement type with oil-coated wire-filter medium; (*c*) constant-effect filter with oil-coated curtain; (*d*) combined air-filter and silencer. The characteristics of these different types are tabulated. Sketches are also given of various types of diesel engine air-intake systems with and without intake silencers. The paper finally discusses the question of filter maintenance. A. S.

896. Diesel-electric booster stations for Iraq pipeline. Anon. *Gas Oil Pwr*, 1949, **44**, 365–9.—Two booster stations on the 16-in Iraq pipeline each contain six diesel-electric pumping units, and each unit consists of engine, alternator, induction motor, and pump, all working together and independently of any other unit. Outputs are regulated by varying the speed of the prime mover.

The engines are sixteen-cyl Crossley Premier *vis-à-vis* horizontal units with cyls of 17½-in bore and 23-in stroke. Pressure-charging is employed, and the rating is 2000 b.h.p. at 250 r.p.m. with a b.m.e.p. of 71·4 p.s.i. and piston speed 960 ft/min. A 1500-kVA 3300-V alternator is disposed between the two eight-cyl sections of the engine, and since it is solidly coupled to the crankshafts on either side, the whole mass can be considered as a mechanically symmetrical system.

The alternator supplies current to a 1800-h.p. squirrel-cage motor which operates a centrifugal pump capable of handling 3800 g.p.m. against a total head of 1370 ft when running at 965 r.p.m.

When starting the engine is run at *ca* 100 r.p.m. to warm up, then the pump motor is started by applying excitation to the alternator from an independent pilot exciter set, and synchronous speed is attained in 15 sec. This method of starting gives a smooth acceleration to the oil in the pipeline. When synchronism is achieved running speed is attained by speeding up the diesel, and a variation in pump speed from 500 to 1000 r.p.m. is possible. At each station arrangements are made so that each pump can run individually or in series with any other pump, and discharge pressures between 200 and 1150 p.s.i. can be obtained without throttling the engine. H. C. E.

897. Combustion problems of gas turbines. I. Lubbock. *Rev. Inst. franç. Pétrole*, 1949, **4**, 625–35.—Conditions necessary for establishing a stable flame are considered, and diagrams given showing typical furnace and burner lay-outs. In gas turbines high flame velocity raises problems of flame maintenance. Dilution in primary combustion zone of a gas turbine is necessary to cool chamber walls, but excessive dilution results in incomplete combustion; approx 100% excess air is the limit. Heat output in a gas turbine is approx 27×10^6 k.cal/m³/hr, *i.e.*, about 100 times that in a steam-boiler. Owing to high air velocity necessary, eddies have to be formed in which rapid air movement can be maintained without excessive translational velocity. Pressure drop in gas turbines is $\propto$ (combustion rate)$^{1\cdot25}$, typical pressure drop is 140 g/cm². Factors in the design of turbine combustion chambers are discussed and also fuel properties necessary for adequate pulverization; the limiting visc at lowest temp is approx 15 cs, and a graph is given relating particle size to pressure for mechanical atomization of fuels of varying visc. V. B.

898. High temperatures in gas turbines. T. W. F. Brown. *Motor Ship*, Feb. 1950, **30** (361), 446.—A comparison is made between gas-turbine cycles with inlet temp of 1250 and 2200° F. The use of high inlet temp necessitates cooling; the effect of air- and water-cooling in turbines is examined, and equations are given and used to show the factors controlling cooling loss. A cooling-loss factor is also derived which gives the turbine efficiency obtainable with various degrees of cooling. With an inlet temp of 2200° F, one cycle is examined to show the effect of air- and water-cooling. With water-cooling the steam generated is then considered either to provide an increase in useful power or to pre-cool the inlet air. For greater efficiency the steam should be used to increase the power delivered. Practical considerations and a proposed marine lay-out are given, together with a series of conclusions. Appendices are included giving the assumptions made and derivations of the equations. I. G. B.

899. Tests of Ruston gas turbine. Anon. *Motor Ship*, Feb. 1950, **30** (361), 440.—Further details of this installation are given after an inspection of the set running on 80% load. Certain minor improvements are in hand with a view to improving efficiency. It is hoped to run the turbine on a heavier fuel than gas oil, and modified designs of combustion chamber will be tried in due course. I. G. B.

900. New Bolinder oil engine. Anon. *Gas Oil Pwr*, 1949, **44**, 374.—This Swedish marine unit, which is a low-compression, two-stroke, crankcase-scavenging engine, is built in two sizes to give outputs of 145 and 200 b.h.p. at 325 and 280 r.p.m. respectively. No reduction gears are fitted. The fuel injectors are so designed that at light

loads a hand-operated lever on each injector closes the central spray orifice and allows fuel injected through the side orifices to impinge on the hottest part of the combustion-chamber surface, and a high temperature is thus maintained, enabling the engine to accept full load immediately. H. C. E.

901. Development of the Doxford engine during the last decade. W. H. Purdie. *Motor Ship*, Feb. 1950, **30** (361), 452.—This is an extract from a paper read before the North East Coast Institution of Engineers and Shipbuilders on January 13, 1950, and described the modifications which have been made in the Doxford engine during the war and post-war years. I. G. B.

902. Patents. B. H. Eaton. U.S.P. 2,493,120, 3.1.50. A method of internally cleaning bearings of I.C. engines by application with air pressure of a solvent to the bearings and crankcase.

H. B. Jaynes. U.S.P. 2,493,350, 3.1.50. A lubrication apparatus for I.C. engines.

W. V. Falcon. U.S.P. 2,493,481, 3.1.50. An I.C. engine.

C. C. S. LeClair, assr to Tecalemit Ltd. U.S.P. 2,493,490, 3.1.50. A lubricating system adapted to the use of grease having a too heavy consistency to flow freely.

W. Foden and E. Twemlow, assrs to Fodens Ltd. U.S.P. 2,493,532, 3.1.50. Cooling arrangement of compression ignition I.C. engines.

H. A. Chubbuck, assr to Ford Motor Co. U.S.P. 2,493,617, 3.1.50. An oil separator for the recovery of oil droplets suspended in crankcase vapours in an I.C. engine. C. F. S.

MISCELLANEOUS.

903. 1950 demand seen as nearly 6·5 million barrels daily. E. T. Knight. *Oil Gas J.*, 26.1.50, **48** (38), 194.—Probable rates of operations of the oil industry in the U.S.A. for 1950 are discussed.

The difficulties of forecasting absolute data are demonstrated by comparison between estimated and actual volumes in 1949.

Tables show demand and supply of petroleum products, motor vehicles, and refinery runs by districts. G. A. C.

904. U.S. pipe-line systems gain 15,000 miles during 1949. P. Reed. *Oil Gas J.*, 26.1.50, **48** (38), 229.—The 15,000 miles of pipeline laid in 1949 in the U.S.A. is an increase of 50% over 1948 and the post-war annual rate of 10,000 miles.

Tables show principal domestic crude-oil, products, and natural-gas pipeline projects under way and planned. G. A. C.

905. Industry adding billion feet daily to processing capacity. R. B. Tuttle. *Oil Gas J.*, 26.1.50, **48** (38), 218.—A survey is given of company plans for expansion of the natural-gas-processing plants in the U.S.A.

Capacity in 1950 is expected to reach 32 million gal daily.

Tables show plant-building projects completed in 1949 and under way. G. A. C.

906. 1950 booms as year of strong refinery-expansion activity. R. B. Tuttle. *Oil Gas J.*, 26.1.50, **48** (38), 209.—Refinery construction completed during 1949 in the U.S.A. brought refining capacity to 7 million b.d.

Tables show active refinery-building projects, and projects completed in 1949 in the U.S.A. and Canada; with capacity rating, status, and completion date. G. A. C.

907. The Canadian Mineral Industry in 1947. Anon. Bull. 827, Bureau of Mines, Canada Department of Mines and Resources. Ottawa: Govt. Printer, 1949. Pp. 134 + v.—A review of the mineral industry of Canada during 1947. Total crude-oil production amounted to 7,731,299 brl in 1947 (7,604,354 brl in 1946). It was in 1947 that the Leduc field came into production with a total yield for the year of 372,427 brl.

The Turner Valley area produced 5,022,350 brl of crude compared with 5,937,362 brl in 1946. Details are given by fields. Particulars of natural-gas yield are also given. J. S.

908. How to establish reduction to practice of a chemical invention. R. T. McLean. *Chem. Ind.*, Dec. 1949, **65** (6), 882.—In the U.S. patents are granted to the first inventor, and not, as in some countries, to the first applicant. Therefore, before an inventor can claim the patent rights accruing from his invention, he must have established " conception," *i.e.*, complete mental grasp of the substance of his invention, and also " reduction to practice " or the fact that the invention has been practised and its usefulness established.

The rules for determining priority of invention are :—

(1) The inventor with the first conception of the idea and the first reduction of the idea to practice is always the first inventor.

(2) The inventor with the first conception who, following his conception, is diligent in reducing his invention to practice is the first inventor, whether the inventor with the second conception has the first reduction to practice or not.

(3) The inventor with the first reduction to practice is the first inventor, even if he was the second to have the conception, unless the inventor with the first conception was diligent in reducing to practice.

Conception is relatively easy to prove by records, etc., but proof of reduction to practice often presents difficulties. To be assured of the outcome of a contest of patent rights, the inventor should be able to show that his invention has been carried out in all its stages by an independent individual, not a co-claimant. O. M.

909. Solving mixing problems. F. H. Slade. *Chem. Prod.*, Jan. 1950, **13** (2), 57.—Design of efficient mixers, particularly for dry powders, is controlled mainly by the following requirements : (1) a degree of mixing sufficient to yield the desired results ; (2) a satisfactory rate and direction of motion of the entire body of material must be established and maintained.

The first of these applies to efficient mixing over a restricted volume, while the latter provides for the facilities for lifting the material in a vertical direction to overcome gravitational effects and for horizontal motion in opposite directions.

In the light of these requirements, the following types of mixes are discussed :—

Paddle-blade, Propellor, Turbine, and Dry Blenders.

New developments of these basic types are exemplified by the F.Y.T. mixer for dry powders, which causes the components of the mix to follow a figure-of-eight motion, and combinations of basic types with more modern mixers to allow them to deal with high-viscosity mixtures. O. M.

910. New micro methods ease storage and finding of facts. Anon. *Chem. Ind.*, Nov. 1949, **65** (5), 717.—The presently available forms in which information can be most easily distributed are microfilm, microcards, micro-combination (combining microfilm and microcards), and micro- and mini-prints. The last form can be read with the naked eye or with the help of special reading-glasses. Apart from being easily transportable, these forms have the advantage of being more permanent than paper, and their use reduces risk of damage to original manuscripts and other valuable publications due to continuous handling. A new development of great importance in this field is the advent of the Rapid Selector, which, it is hoped, will enable literature searches on given subjects to be carried out in a small fraction of the time at present necessary for such an investigation. O. M.

911. The problem of prices in petroleum industry. L. Zukrowski. *Nafta*, Sept. 1948, **4**, 301–4.—Prices of petroleum products cannot be based on production costs, because many products are made at the same time, *e.g.*, value of asphalt and gasoline is inversely related to the work required for their production. Formulæ are usually worked out to give answer to the problems posed. Prices are shaped according to requirements of the markets and profits taken out of only a few of the proceeds. M. S.

912. What is dangerous machinery? Anon. *Industrial Bulletin*, Jan. 1950, **18** (180), 2.—The article is concerned with a case before the High Court where the point

at issue was whether part of a machine which had admittedly caused an injury was dangerous within the meaning of Section 14 (*i*) of the Factories Act 1937. The Court decided that the part in question was not dangerous and that no breach of the Act had been committed. Although at first sight this decision appeared to be revolutionary, on further consideration it appears to be in line with other High Court decisions made during the past fifty years. The case under consideration is outlined, and a number of similar cases are reviewed. A. S.

913. Fluidization technique applied to direct distillation of oil from bituminous sand. P. E. Gishler. *Canad. J. Res.*, 1949, **27F** (3), 104–11.—The fluidized-solids technique has been applied on a laboratory scale to the flash distillation of oil from Alberta bituminous sand. Highest yields of oil were obtained in the temp range 460–500° C. At lower temp distillation was incomplete and the charge tended to lump. Above 500° C cracking became more severe, resulting in increased formation of light oil and gas. The oil yield at 500° C was 76%, the remaining 24% producing approx equal weights of coke and gas. D. F. J.

914. Patents. W. H. Roberts. U.S.P. 2,493,504, 3.1.50. A pipeline cleaner, loading, and clean-out device.

J. C. Zimmer and A. J. Morway, assrs to Standard Oil Development Co. U.S.P. 2,493,516, 3.1.50. Chemically treating a ferrous-alloy machine element to improve load-carrying capacity of the finished surface, with a boiling aqueous solution composed of boric acid of 5% concentration for 15–30 min.

R. C. Baker and W. S. Althouse, Jr., assrs to Baker Oil Tools Inc. U.S.P. 2,493,650, 3.1.50. A valve device of tear-drop shape for well conduits, having a spherical nose portion and stabilizing fins, a weighting material in a hollow body having a greater specific gravity than the material of the body. C. F. S.

BOOKS RECEIVED.

A.S.T.M. Standards on Petroleum Products and Lubricants (With Related Information). Philadelphia, Pa.: American Society for Testing Materials, 1949. Pp. 734 + xvi. $5.50.

This latest (November 1949) compilation of *A.S.T.M. Standards on Petroleum Products and Lubricants* (*With Related Information*) brings together most of the A.S.T.M. standards, test methods, and specifications used in this field. (The methods of test for knock rating of engine fuels are issued in a special manual and not included in this compilation.)

Prepared by A.S.T.M. Committee D-2, this edition gives in their latest form 120 A.S.T.M. standards, including 102 test methods, twelve specifications, two lists of definitions relating to petroleum and rheological properties of matter, two tentative recommended practices for the purchase of uninhibited mineral oil for use in transformers and in oil circuit-breakers, and for designating significant places in specified limiting values; and other material.

New material includes tentative test methods for: aniline point and mixed aniline point of hydrocarbon solvents; benzene and toluene by ultra-violet spectrophotometry; hydrogen in petroleum fractions by the lamp method; olefinic plus aromatic hydrocarbons in petroleum distillates; acetylene in polymerization-grade butadiene by silver nitrate method; oxygen in butadiene vapours by manganous hydroxide method; peroxides in butadiene by ferrous–titanous method; separation of residue from butadiene; butadiene dimer in polymerization-grade butadiene; non-volatile residue of polymerization-grade butadiene; sodium in lubricating oils and lubricating-oil additives; distillation range of lacquer solvents and diluents; and tentative methods of testing and standardization of etched-stem liquid-in-glass thermometers.

Appendices include, in addition to the report of Committee D-2, proposed methods of test for: determination of micro-cone penetration of lubricating grease; apparent viscosity of lubricating greases; sulphur in petroleum products by the CO_2–O_2

method; boiling-point range of polymerization-grade butadiene; phosphorus in lubricating oils, lubricating-oil additives, and their concentrates; bromine number of petroleum distillates (colour indicator method and electrometric method). Also, proposed definitions, functions, types, and designations of cutting fluids; carburettor jacket for use with motor and research methods to rate high-vapour-pressure fuels; method for determination of colour index of petroleum products by photo-electric colorimeter; and measuring the temperature of petroleum and petroleum products.

A.S.T.M. Standards on Gaseous Fuels. Philadelphia, Pa.: American Society for Testing Materials, 1949. Pp. 98. $1·15.

This special compilation contains the three standardized tests developed by A.S.T.M. Committee D-3 on Gaseous Fuels.

Calorific value of gaseous fuels by the water-flow calorimeter (*D* 900). This method is intended for use when water-flow calorimeters are used to determine the total and net calorific values of fuel gases. It is restricted to gaseous fuels having total calorific values in the range from 300 to 3000 B.Th.U/s.cu.ft.

Specific gravity of gaseous fuels (*D* 1070). These methods are intended for determining the specific gravity of gaseous fuels, including liquefied petroleum gases, in gaseous state at normal temperatures and pressures for any purpose where it is desired to know the relative density of a gas or gases as compared to the density of dry air at the same temperature and pressure.

Measurement of gaseous fuel samples (*D* 1071). Applicable to the measuring of gaseous fuel samples, including liquefied petroleum gases, in the gaseous state at normal temperatures and pressures for any purpose where it is desired to know the quantity of gaseous fuel or fuel samples under consideration.

B.S. 876 : 1949. Hand Hammers. London: British Standards Institution, 1949. Pp. 31. 3*s*. 6*d*. net, post free.

This standard applies to hand hammers for general purposes.

B.S. 1560 : 1949. Steel Pipe Flanges and Flanged Fittings for the Petroleum Industry. London: British Standards Institution, 1949. Pp. 78. 12*s*. 6*d*. net, post free.

Applies to cast- and forged-steel flanges and flanged fittings in seven classes for primary service pressure ratings of 150–2500 p.s.i.

B.S. 1609 : 1949. Press Tool Sets. London: British Standards Institution, 1949. Pp. 45. 7*s*. 6*d*. net, post free.

Covers press-tool sets for single-acting presses. A recommended standard terminology is included.

B.S. 1615 : 1949. Anodic Oxidation Finishes. London: British Standards Institution, 1949. Pp. 23. 3*s*. net, post free.

This covers the performance and testing of anodic coatings on aluminium and aluminium-base alloys.

B.S. 750 : 1950. Underground Fire Hydrants and Dimensions of Surface Box Openings. London: British Standards Institution, 1950. Pp. 14. 2*s*. net.

B.S. 888 : 1950. Slip (or Block) Gauges and their Accessories. London: British Standards Institution, 1950. Pp. 23. 3*s*. net.

Applies to slip gauges of rectangular form up to 4-in and 100-mm sizes.

B.S. 1570 : 1949. Flanged Steel Plug Valves for the Petroleum Industry. London: British Standards Institution, 1949. Pp. 32. 7*s*. 6*d*. net.

Covers flanged steel plug valves, having two-way coaxial ports, for use in refineries, natural-gas and natural-gasoline plants, and for other service. They are not intended for well-head control and flow-line valves.

B.S. 1599 : 1949. Identification Numbers for Cylinders of Internal Combustion Engines. London: British Standards Institution, 1949. Pp. 10. 2*s*. net.

B.S. 1610 : Part 1 : 1950. Verification of Testing Machines. London: British Standards Institution, 1950. Pp. 11. 2*s*. net.

Deals with the verification under load of testing machines.

B.S. 1621 : 1950. Bitumen Macadam with Crushed Rock or Slag Aggregate. London : British Standards Institution, 1950. Pp. 15. 2*s*. net.

Transactions of the Institution of Chemical Engineers. Vol. 25, 1947. London : The Institution, 1950. Pp. 199 + xxii.

Symposium on Particle Size Analysis. London : The Institution of Chemical Engineers, 1950. Pp. 145. Price £2 2*s*.

The full report of the symposium which was held in London on February 4, 1947, in collaboration with the Road and Building Materials Group of the Society of Chemical Engineers.

APPLICATIONS FOR MEMBERSHIP OR TRANSFER.

April 1950.

The following have applied for admission or transfer to the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidates.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Applications for Membership.

Adams, Austen Leslie, resident engineer, Anglo-American Oil Co. Ltd. (*G. S. Vickers ; J. I. G. Elsden.*)

Andrews, Raymond Edward, oil accountant, Consolidated Refineries Ltd. (*S. G. Tidy ; E. C. Johnson.*)

Asquith, Ernest, assistant chief engineer, Anglo-American Oil Co. Ltd. (*G. Noble ; K. Parsonage.*)

Batho, Sir Maurice Benjamin, export promotion manager, Messrs. C. C. Wakefield & Co. Ltd. (*G. H. Thornley ; L. G. Packham.*)

Borrows, Edward Teggin, chief organic chemist, Petrocarbon Ltd. (*E. J. Dunstan ; G. H. Harries.*)

Daniels, Milton Y., chemist, Anglo-Iranian Oil Co. Ltd. (*L. A. Wilshere ; A. Aghdaey.*)

Doyle, Terence Marcellus James, assistant installation supervisor, Sarawak Oilfields Ltd. (*G. F. Hazzard ; C. R. Middleton.*)

El-Sawi, Abd el Dayem, chief chemist, Egyptian Government Petroleum Refinery. (*I. Xoussef ; W. Farag.*)

Farr, William, administrative assistant, National Oil Refineries Ltd. (*J. A. Green ; E. J. Horley.*)

Gardiner, Leonard Henry, assistant engineer, Anglo-Iranian Oil Co. Ltd. (*R. Stansfield ; J. G. Withers.*)

Glover, Thomas Bernard, manager, Shell-Mex Argentina Ltd. (*G. C. Carr ; C. T. Wellington.*)

Holloway, Stanley Dennis, assistant engineer, Petroleum Development (Qatar) Ltd.

Humphreys, Robert Frank, instrument mechanic, "Shell" Refining & Marketing Co. Ltd. (*A. W. Evans ; N. Lockwood.*)

Jones, James Eric, leading draughtsman, Regent Oil Co. Ltd. (*W. E. Skilbeck ; G. Sell.*)

McLeod, John William, technical representative, Messrs. Richard Klinger Ltd. (*E. L. Lomax ; F. Peel.*)

Majumdar, Amar Nath, manufacturing chemist, Silvertown Lubricants Ltd. (*C. A. Featherstone ; L. O. Maskell.*)

Maynard, Alan Henry, clerk, Universe Petroleum Co. Ltd. (*R. H. Read.*)

Pelmore, James Robert, Shell Petroleum Co. Ltd. (*H. N. Bassett ; R. G. Mitchell.*)

Pike, D. A., student, Birmingham University. (*F. H. Garner ; F. Morton.*)

Robinson, John Howe, installations engineer, Shell-Mex Argentina Ltd. (*G. C. Carr ; C. T. Wellington.*)

Shragah, Samuel, Senior Administrative Development Dept., Shell-Mex & B.P. Ltd. (*G. L. Coles ; J. G. Caffarey.*)

Simpson, George, works chemist, Messrs. W. B. Dick & Co. Ltd. (*H. Macarthur ; J. Romney.*)

Smith, Adam Clayton, auditor, Messrs. Fitzpatrick, Graham & Co. (*L. A. Burke ; A. Richard.*)

Smith, Harold Harding, chief technical assistant, Messrs. Babcock & Wilcox Ltd. (*C. W. Knighton ; J. S. Parker.*)

SMITH, Horace William, director, Universe Petroleum Co. Ltd. (*C. Chilvers ; J. G. Caffarey.*)

THORNYCROFT, Oliver, Director of Aeronautical & Engineering Research, Admiralty. (*F. L. Garton ; I. Lubbock.*)

TROWBRIDGE, George William Job, works manager, The Kingston Instrument Co. Ltd. (*H. De Wilde ; H. J. Wilkinson.*)

WALEY, Guy Felix, departmental manager, Shell Petroleum Co. Ltd. (*A. E. Scriven ; O. F. Thompson.*)

Transfers.

CARTER, Douglas Henry, general manager, Head Wrightson Processes Ltd. (*R. G. Fisher ; T. L. Bonstow.*) (*Associate Member to Fellow.*)

HIGGINS, George Ormsby, general manager, Sarawak Oilfields Ltd. (*J. B. Kay ; E. J. Sturgess.*) (*Associate Member to Fellow.*)

PETTY, Donald Stuart, research student, Birmingham University. (*F. H. Garner ; F. Morton.*) (*Student to Associate Fellow.*)

TRASLER, Philip Herbert Brigstock, co-ordination officer, Trinidad Leaseholds Ltd. (*B. G. Banns ; N. B. Heck.*) (*Member to Fellow.*)

NEW MEMBERS.

The following elections have been made by the Council in accordance with the By-Laws.

Elections are subject to confirmation in accordance with the By-Laws.

As Fellows.

LEONARD, J. M. NICHOLSON, C. P.

As Associate Fellows.

BIGGS, R. R. FLATOW, G. J. F.
EASTLAKE, A. L. WALLERSTEINER, W. K. S.
EATWELL, H. J. WOOLNOUGH, E.

Transferred from Member to Associate Fellow.

FIRTH, W. W.

As Associate Members.

GREEN T. S. MARTIN, F. P. F.
HARRIS, E. V. SANTHIRASENAN, V.

As Student.

CUZACK, J. G.

As Member Companies.

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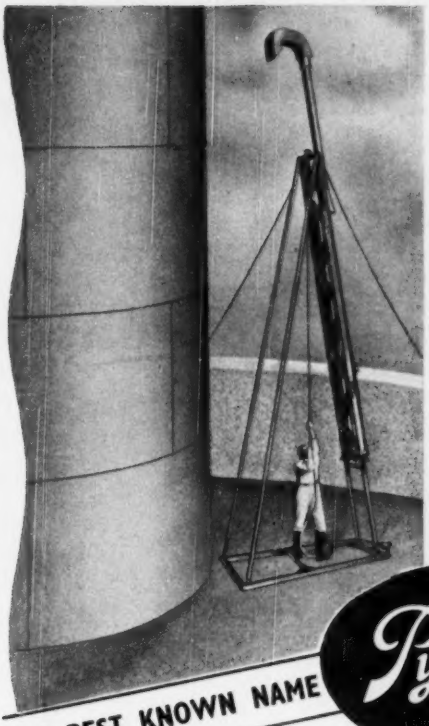
CORRECTION.

SCALLAN, J. F. P. In the *Journal* for December 1949, Mr Scallan was shown as being with the "Shell" Refining & Marketing Co. Ltd. This is incorrect, as Mr Scallan is with the Shell Petroleum Co. Ltd.



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NEW PORTABLE TELESCOPIC FOAM TOWER

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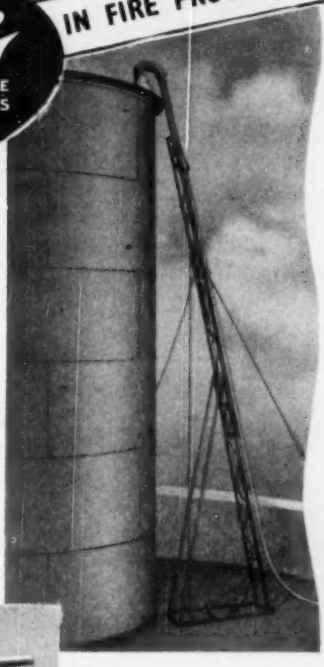

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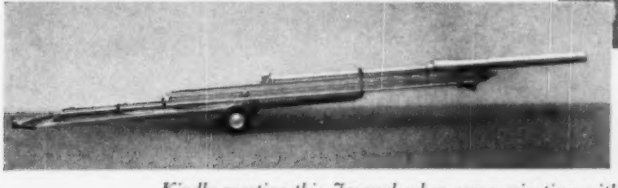
- They fulfil three distinct purposes. (1) As an additional aid to fixed Foam Installations. (2) For tanks without fixed foam inlets and (3) for floating-roof tanks.
- These portable units are available, where preferred, as an alternative to Fixed Foam Installations or Mobile Foam Tenders.
- Full particulars of this latest fire-fighting development can be obtained by writing to Dept. J.I.P., The Pyrene Company Ltd., 9 Grosvenor Gardens, London, S.W.1. 'Phone: VICtoria 3401.



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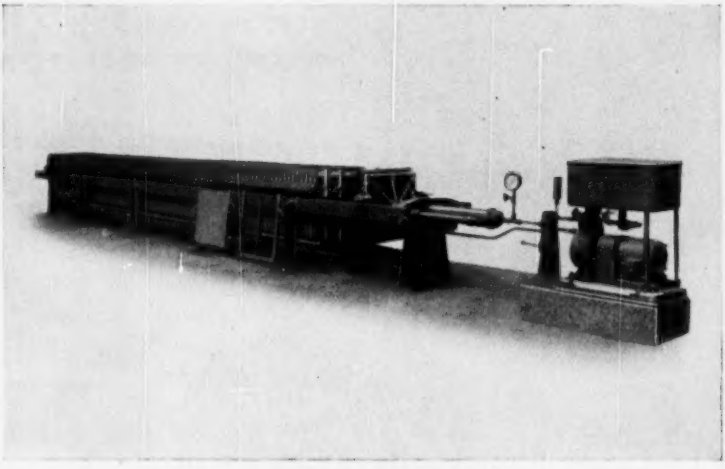

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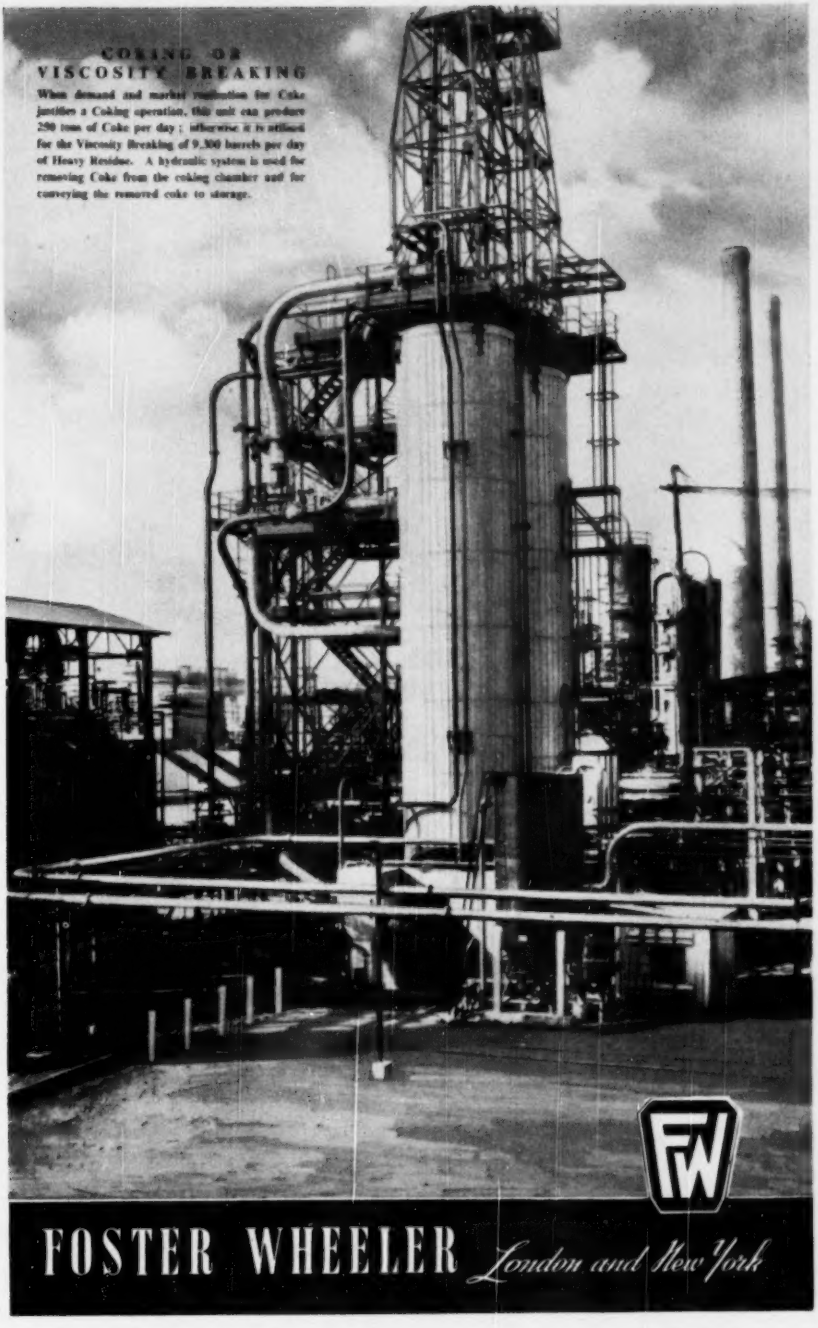
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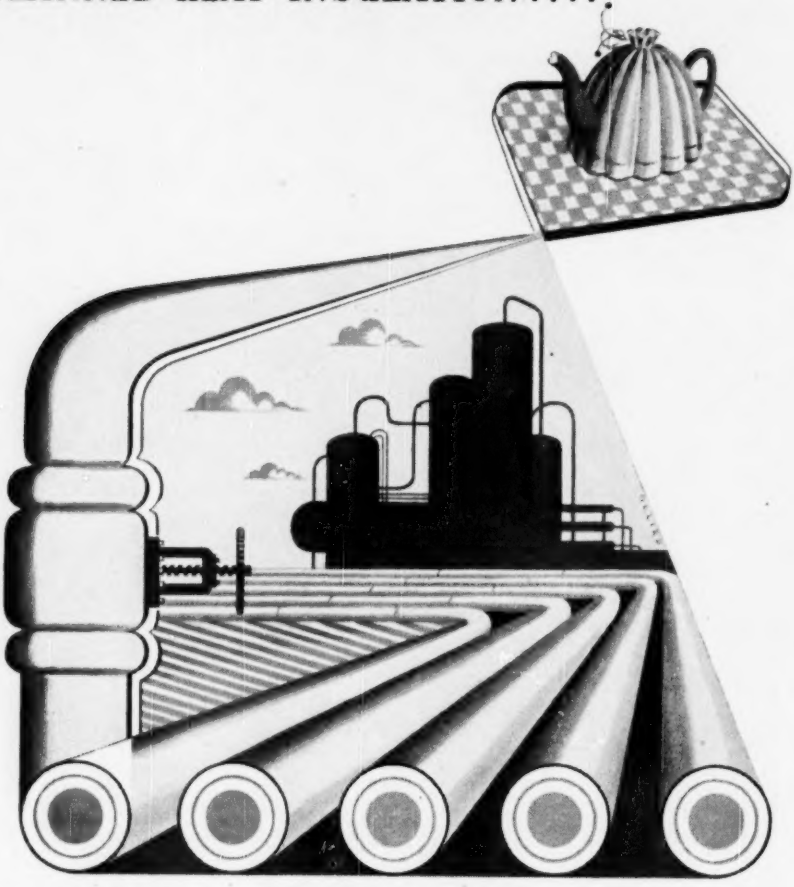

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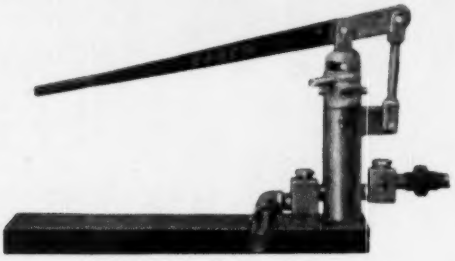

THIS rugged, light-weight, high-pressure pump originally was developed for removing cores from the Baker Cable Tool Core Barrel, and hundreds now are in use around the world for this specialized service.

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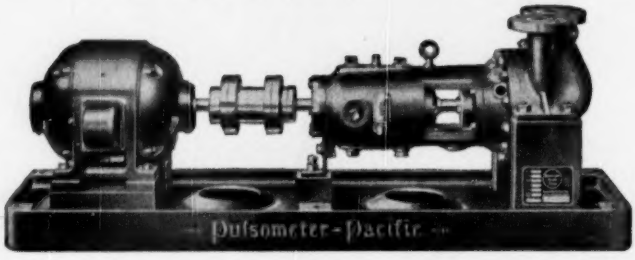

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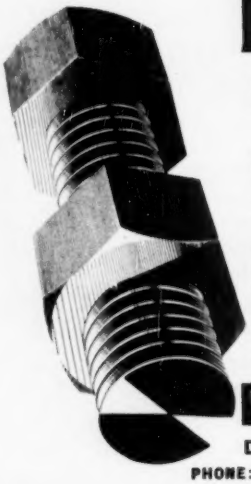

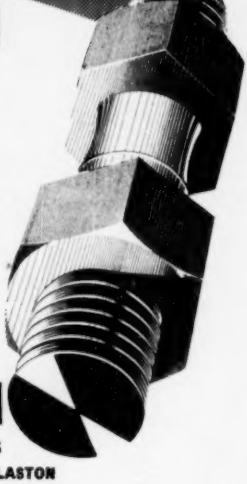

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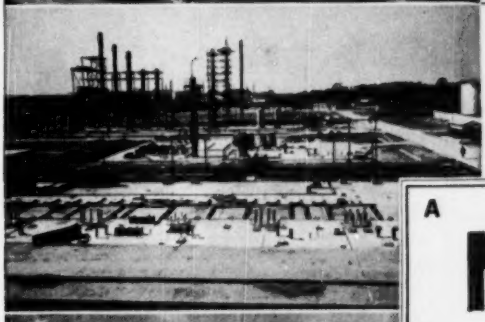

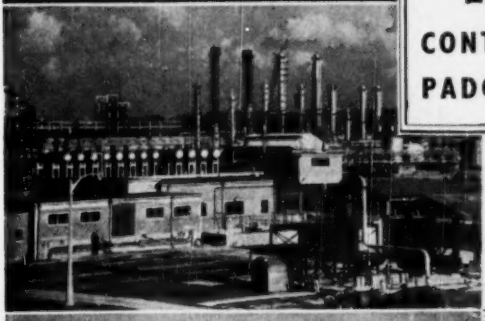

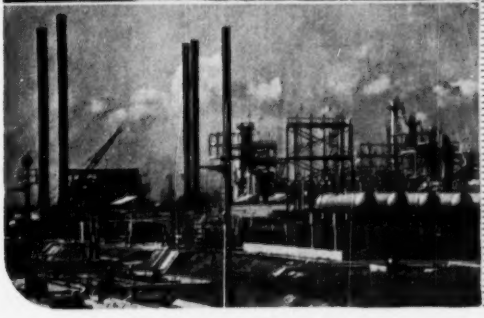

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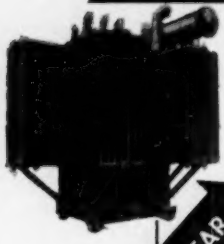

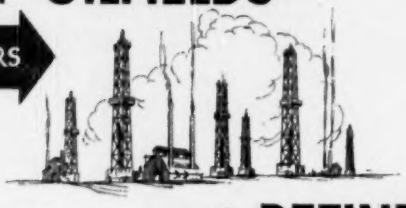

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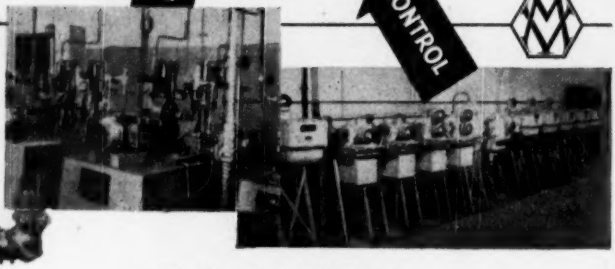

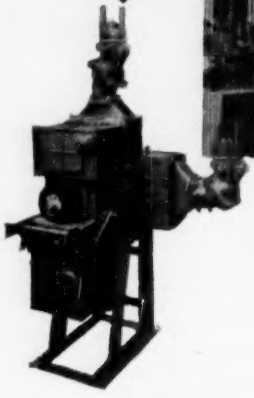

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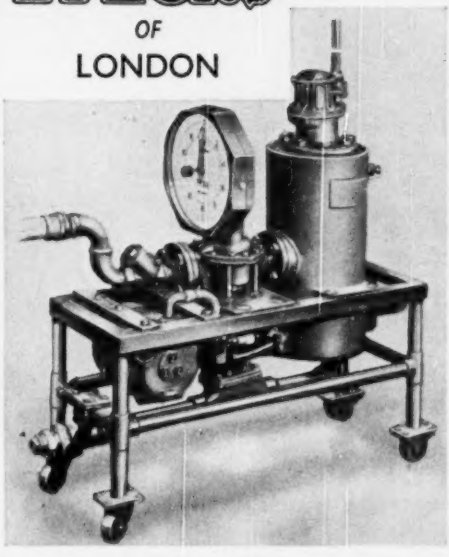

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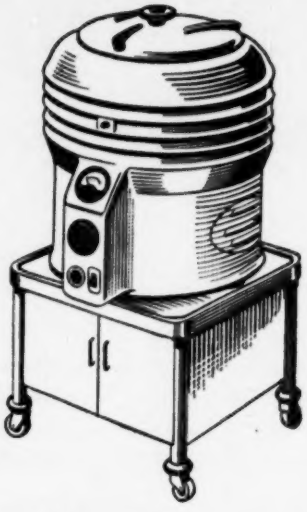

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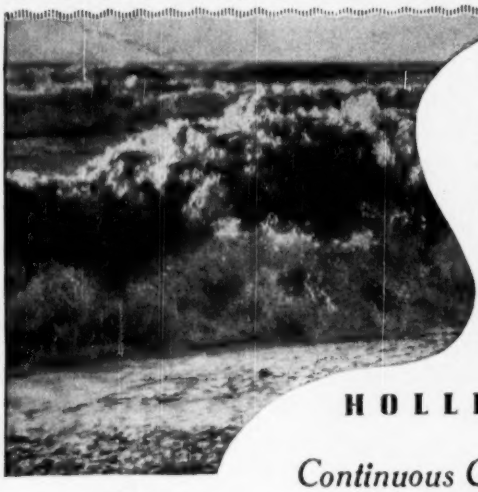

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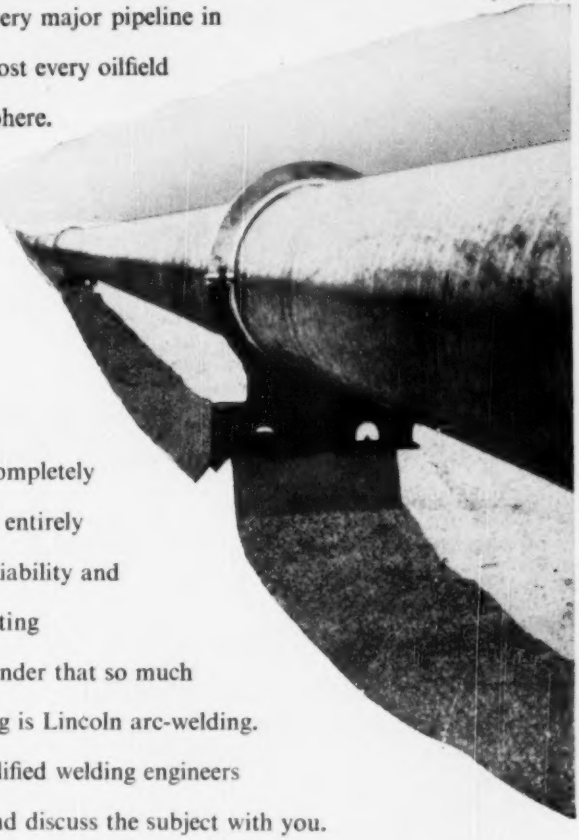

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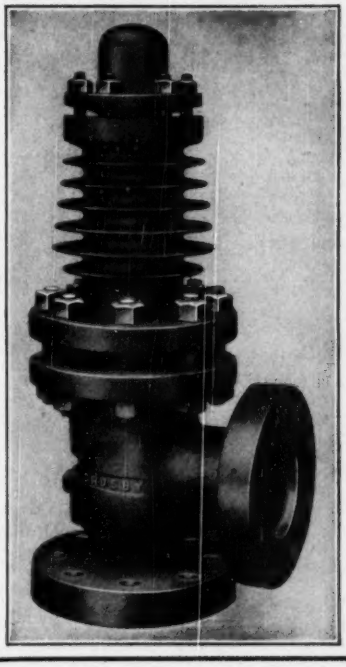

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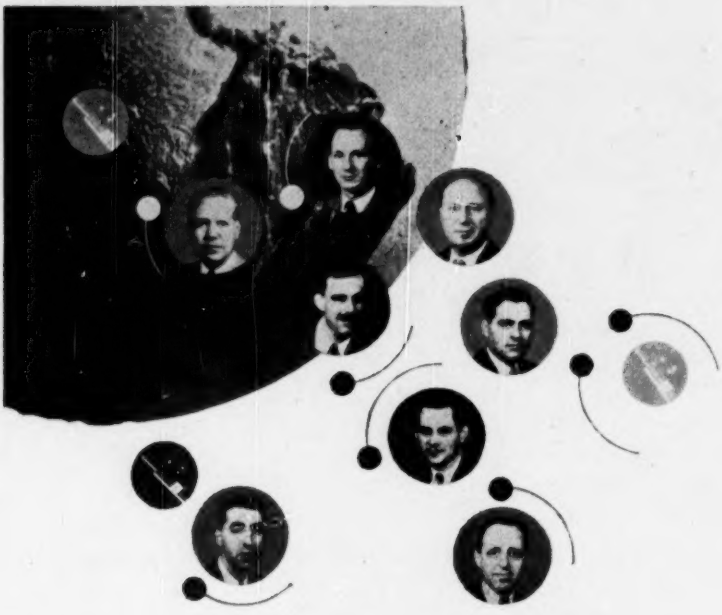

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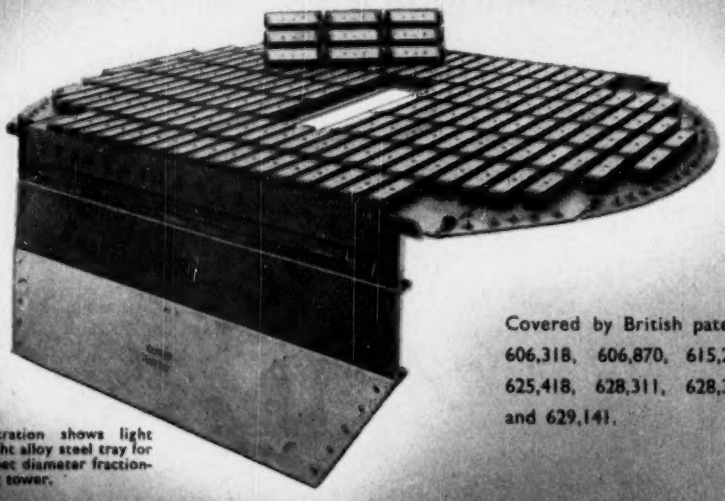

Illustration shows light weight alloy steel tray for 12 feet diameter fractionating tower.

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